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A good character is the best tombstone, those who love you, and were helped by you will remember you when Forget-me-Nots are withered. Carve your name on hearts and not on marble.—SPURGEON.

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LABORATORY ACTIVITIES—WHY?

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Why should we have laboratory activities? Everyone who is in any way concerned with science education needs to give this question his soul-searching attention. So often today laboratory activities are being carried on simply because they have become entrenched in the science program. For many individuals, the mental image conjured up by the "scientist," a man pottering about in a room filled with grotesque glassware and occult apparatus, serves more than sufficiently to warrant laboratory flurry and bustle. Little need is felt to justify lab activities; effort to prove their place or value is largely ignored. For teachers and pupils alike, laboratory activities are looked forward to because they offer release from the monotony of classroom lecture and discussion.

If one felt the necessity to apologize for laboratory activities, he would have little difficulty in drawing up an impressive list of arguments in their defense. Tradition, psychology, philosophy, and the nature of science itself yield support for the utilization of laboratory activities. The point is, however, that any argument used should be in keeping with the spirit and method which have enabled science to contribute so greatly to the tremendous strides of progress by modern civilization. Not every reason is equally sound or cogent when viewed against this criterion. Let us examine the case for laboratory work.

Tradition assumes a large role, disproportionately so, in the place accorded lab activities in the science program. Lab activities have come to be naturally associated with science instruction. Especially has this become increasingly true in the practice of high schools since the start of the present century. However, in the development of a

rationale, tradition gives only feeble endorsement to most practices, particularly to things related to science. The answer to the question must be sought in something more fundamental than tradition.

From the findings of psychology, laboratory activities gain strong vindication. Psychologically speaking, laboratory work furnishes learning experiences. On the basis of what is known about the learner and the learning process, laboratory activities command a very favorable position in the science program. They incorporate many acceptable principles of the educative process. For illustrative purposes, a few of these principles should be enumerated:

1. Psychology holds that a child is innately curious. He is inherently characterized by a searching, questioning disposition. The science laboratory is a natural for children and youth. For the young investigator, the laboratory becomes a rich hunting ground.
2. Children learn through doing. Overt "doing" is an essential element of learning. Laboratory experiences introduce pupil activity into the learning process. The nature of lab activities lends itself well to meeting children's needs for learning through purposeful doing.
3. Pupils differ in abilities and readiness—even within the same grade. Laboratory activities recognize this fact. They can be geared to the level of pupil abilities and interests and may be used at any grade level of instruction.
4. Motivation is an essential component of learning. Lab activities generate an intrinsic motivation when they are organized about meaningful problems. Moreover, the employment of an especially wide variety of materials and equipment possible in lab activities is a significant motivator by itself.
5. Learning follows a developmental sequence. The learning of concepts and principles is promoted to the extent that new experiences find a place in the over-all pattern of experience and take on meaning. As lab experiences enable learners to build meanings, activities can be planned so that they further more generalized, abstract understandings. In other words, lab activities are excellent for proceeding from the concrete to the abstract and from the known to the unknown. Not only do lab activities give recurrent contacts with principles and concepts, but they also provide a spiraling and enlarging of growth in the development of problem-solving and instrumental skills and also in the cultivation of desirable attitudes, appreciations, and interests.
6. It is meaningful learning which transfers to new situations. Insofar as transfer of training is concerned, laboratory activities

exemplify an area where problems can be arranged with an orientation to the kinds of problems which individuals meet up with in their daily life. Direct experiences with the kinds of problems children will deal with will have the greatest transfer value. Lab activities have been found to be well suited for teaching problem-solving skills. The transfer value of lab activities is not negligible if they are properly handled.

The number of psychological principles of learning has by no means been exhausted. What is known of the learner and the learning process holds much additional significance for laboratory activities. To treat adequately all implications of research for laboratory instruction would require a great deal more space and would go beyond the intent of this paper. In lieu of that, some brief attention might be given to the relationship of philosophy to laboratory work. From a philosophical point of view, why should we have laboratory activities?

Those who hold that the structure of society is not static but is changing constantly, those who affirm that change is inevitable, and those who maintain that man must adjust to changing conditions will welcome laboratory activities as an integral part of science instruction. Change is inevitable as man achieves greater understanding and knowledge and as environmental conditions change. The educational program must enable young people to adjust to modified conditions. Lab activities can aid in this function by stressing practice in scientific inquiry, in investigation, in the collection of evidence, and in reaching decisions. The critical thinking fostered in the laboratory can be applied to many areas of living and to social problems which confront man in his efforts to lead a rich, meaningful life.

Philosophically speaking, one can note an important function of laboratory work in connection with the school's role in society. As an agency of society, the school in the United States is committed to preparing young people to live successfully in a democracy. The ordered thinking which seems most appropriate for the democratic citizen is the general pattern of the scientific method with its emphasis on critical and reflective thinking. Lab activities afford excellent opportunities for student experience in reflective thinking. Questions relating to "how," "what would happen if," and "why" are mandatory in laboratory work. Critical intelligence in a democracy also implies a systematic, experimental attack on problems. Working through a problem necessitates thinking through materials and equipment as to their usefulness in arriving at an answer or solution to a problem. Lab activities are especially conducive to the development of the critical thinking needed in a democracy.

Laboratory activities may thus be said to be in keeping with the

criteria of a democratic ideology. Besides calling upon the exercise of intelligence for the solution of problems, laboratory activities permit respect for the individual personality and for the promotion of mutual individual and group responsibility—all important elements of a functioning democratic society. The scientific method as can be taught through lab activities is in harmony with the spirit of democracy and its regard for the worth and dignity of each personality. By this is meant that in the scientific method the emphasis is on the solution of the problem, not the dissolution of the human personality. In regard to the third criterion, that of promoting mutual individual and group responsibility, lab activities provide frequent opportunities for pupils to participate in planning and to share responsibility in the pursuit of individual and group projects. The science laboratory is a setting where problems can be attacked by individuals or by groups. Laboratory activities are consistent with the philosophy and criteria of a democratic society.

In demonstrating the relationship of psychology and philosophy to laboratory activities, there has been a natural and unavoidable encroachment upon what serves as the ultimate justification of laboratory experiences. The extent to which a practice can be used for what it is most suitable for furnishes the most valid reason for employing it. In the final analysis, teachers should utilize laboratory activities because through them they can touch the heart of science. The heart of science is not its content but its method. The progress of science has been accomplished through the formation of an approach which is becoming increasingly applicable to a wide range of problems. There is a growing belief that humankind may be relieved of many anxieties by a wider application of science to problems which up to now have not been subjected to the rigors of scientific methodology. Mental illness is a prominent example of what is meant here. When science is approached from the vantage of method, its applications to all kinds of problems—both individual and group—are innumerable.

The utility of the scientific method is easily apparent in almost any direction one may care to look. War, trade, and industry have called upon science to meet new demands, and the scientists have not disappointed. Problems in nutrition, health, and medicine have yielded to the probe of the scientific method. Science is preeminently a method of solving problems. When viewed in this way, science dare not be taught as a body of knowledge. Its life is quickly extinguished by the dry rot of teaching facts and information through the lecture or textbook. Laboratory activities are essential for infusing breath and vitality into what might be just a corpse of technical informa-

tion. Laboratory activities are a positive means for the teaching of science as method.

Unless the pupil is aided in developing a sensitivity to the method by which science has achieved its status, unless he can participate in devising procedures which can be made to yield objective data, he will remain largely ignorant of the real meaning of science. The use of the laboratory, however, does not constitute by itself assurance that a student will understand the role of the scientific method in problem solving. While laboratory activities represent an invaluable means for teaching the real meaning of science, an understanding of the scientific method goes beyond the manipulation of materials and equipment and beyond the verification of textbook information. The scientific method must be instilled into the child as attitudes and habits which will function whenever he is faced by problems. Laboratory activities are excellent for the inculcation of orderly habits such as accuracy, suspended judgment, open-mindedness, and intellectual honesty. That kind of pupil behavior can best be realized when meaningful problems are attacked in the laboratory.

When laboratory activities are planned to teach problem-solving skills, pupils will have attained an approach which will serve them well for the rest of their lives. An understanding of the scientific method growing out of purposeful laboratory activities will find repeated applications in the daily affairs of life. If laboratory activities were not conceived with the possibility of transfer of the scientific method to problems met in everyday situations, they would be of little avail outside the specialized pursuit of science. Laboratory activities are necessary because of the practice they give in solving genuine problems.

Looking backwards for a moment, one can see that the case for having laboratory activities is principally three-fold. First, they should be included in a program of science because they incorporate to a very high degree acceptable principles of learning. Secondly, they can be planned to enhance beliefs basic to a democratic society. Either psychologically or philosophically, lab activities can be readily justified. Finally, however, the fundamental and ultimate reason for having laboratory activities is that they are indispensable for teaching the scientific method. When the laboratory is employed for developing problem-solving skill, one need not be an apologist for lab activities. The unassailable justification for laboratory activities is that they give life and breath to science itself. They are the means for teaching the scientific method.

See Page iv, this issue, for some items you may find very valuable.

CONSERVATION EDUCATION: ERSATZ OR REAL?

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The Premise

Conservation education is the development of right attitudes, appreciations, and skills in the use of natural and historic resources. Conservation is, therefore, a social-moral obligation. The subject matter is the vital needs of the natural and social environment of the immediate locality. Conservation education is needed in all ages: preschool, elementary school, high school, college, and in adult life. Conservation education is a complex interdependence of science, education, sociology, and community living.

The Procedure

It is assumed that the biology teacher who reads this article is acquainted with dichotomous "keys" employed in Botany Manuals. Two alternatives are usually presented for consideration. Eventually ideas are separated and identified. For example, select one of the following as based on the above premise:

1. Conservation education is limited to sitting in the classroom, studying the textbook, and reciting the facts. (Go to Experience 2)
1. Conservation education consists of practical seasonal experiences in the immediate environment in which reference books are used when needed.

This latter choice is scientific procedure. Throughout life individuals have to make a choice based on observations. (Go to experience 6)

Experience 1. This is being written in the first week of November, 1955. Oranges are pouring into the market. Science has taught us that orange juice is "stored sunlight." It contains minerals and vitamins needed for growth and "cold" resistance. The food purchaser has to make several decisions:

1. To purchase whole oranges and squeeze out the juice at home. (Go to 2) or
1. To purchase concentrated orange juice in the can. (Go to 3)
2. "Juice" oranges are thin skinned, heavy, low cost—19 cents a dozen, or
2. "Eating" oranges, thick skinned, may be navel, high cost—50 cents a dozen.
3. Minute Maid, can equals a dozen average oranges, has all original minerals and vitamins, only water content missing, 3 cans 52 cents.
3. Another brand, similar claims, 3 cans 62 cents.

The purchaser realizes that he does not have all the facts. He selects a dozen "juice" oranges and 3 cans of Minute Maid, and discovers additional facts:

1. Juice oranges take two to make a glass; the dozen made 6 glasses (1 quart) at 3 cents per glass.

* "Cap'n Bill," Emeritus Professor Nature Education, University of Massachusetts.

1. Minute Maid directions are to add 3 cans of water, which makes 1½ pints of juice, or 4 glasses at a cost of 4 cents plus per glass.

The purchaser must now decide on savings (1 cent per glass), thrift, time, and convenience. Perhaps there are 10 children in the family. Other factors will influence his decision, such as palatability. Right after World War II, in Germany, the writer tried to eat an *ersatz* meal. The orange drink was a coal derivative. It was at least cool and refreshing. I couldn't "stomach" the meal and gave it to a one-toothed, under-nourished hag. The tears rolled down her face in appreciation. She tried to give me her ever-sharp pencil.

This orange juice experience has been excellent science. It has included up-to-date, practical research. It is related to human conservation. In the states of Florida and California it might have involved the prevention of disease, insects, physical injury such as frost, or harvesting. Orange groves are not a natural resource outside of these two states.

Experience 2. A certain community of 4000 population with forested areas uses the textbook method in high school biology. There is no community recreation program; no swimming pool; no park; no public school camp; no public school forest. The parents commute to a big city. On Hallowe'en eve there are many parties for children. On Hallowe'en Week, 1955, there were many crimes committed by juvenile delinquents; These were their choices:

Burned buildings:	1. Cabin of Rod and Gun Club.
	1. Home of a widow who is on public welfare.
Broken windows	2. Grange Hall (The Grange is very generous with scholarships).
	2. Girl Scout Cabin also built by hard-earned money.
Auto injury:	3. First degree burn.
(No license)	3. Cut finger requiring 7 stitches.

This is not unusual for many communities. This also shows a local need for science and the conservation of property and humans. The aura is *not* pleasing. People usually wait until a problem becomes critical before they act. The action could be unwise. Prevention is more desirable than punishment.

Experience 3. The writer took a week-end trip to Maine. He met a steady stream of cars with 1 to 3 deer corpses on top. He visited a large sporting store. "Sports" were buying all kinds of equipment. Children were getting Scarlet Wool Deer Caps, Alaskan Parkas, a Crow Call (An important step in duck conservation. Crows take a large toll of ducks); Alpaca Lined Coats, Ice Fishing Boots, Maine Guide Shoes, etc. They were all getting appreciations and attitudes. People have plenty of money for things they want. The author has no quarrel with game as a crop.

Experience 4. When the author was a Nature Guide in Yosemite (1924), he and his teen-age son came down a zigzag mountain trail in pitch darkness. We could distinguish between deer bounding off the trail and bears crashing through the underbrush. We could also distinguish the footsteps of a Mountain Lion (Cougar) crunching in the sand. He was following us. When we stopped the cat stopped. We were not too sure whether he was just curious or was planning to jump us. This experience was adventure. It had recreational value. I have described this hike at many camp fires. There is such a thing as adventure value with wild animals.

Experience 5. The local Rod and Gun Club released pheasants. They were so tame one could pick them up in his hand. Shooting these pheasants was similar to gunning in a hen yard. The same club ran a fishing derby and awarded suitable prizes. A fisherman can go fishing, haul home a fish corpse from a market, and call it a good day. He may continue to brag on Monday morning. This leads to the question: *What are we trying to preserve? Things? People? A spirit?* The answer is stated in the premise which has to be returned to again and again. There is such a thing as quality as well as quantity in conservation. There should be inter-organization policies.

Experience 6. For several years the writer was consultant and resource person for Newton, Massachusetts, public school camp movement. The teachers said: "We want to experience the program that our children will do." They went to camp and lived experiences in such things as outdoor first aid, how to use an axe, how to select a stick for brigand steak, predicting weather (it determined program, food, clothing, safety), fire lanes, check dams, outdoor cookery and interdependence, analyzing owl pellets, stalking a heron rookery, fishing through the ice, etc. Each teacher selected an enterprise which he carried to completion for university credit.

Conclusions

After nearly fifty years of leadership training I am sure of this much: Many teachers state a premise and do the opposite. Youth is going to have adventure. If the community does not arrange a program, youth will. Juvenile delinquency is really adult delinquency. Conservation education is done best by providing seasonal, enriching educational experiences in a natural environment. It is not a subject for lazy, untrained, unimaginative biologists. Purposeful teacher-pupil planning enables small groups to underwrite community needs in conservation. Community agencies related to the project should be spirited to cooperate. Local resource personnel should be consulted. Right attitudes, appreciations, and skills are bound to develop. Juvenile delinquency will decrease.

A CONSIDERATION OF THE NATURE OF INDUCTANCE AND CAPACITANCE

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Schelkunoff points out that "the ideas of resistance, inductance, and capacitance, simple as they are, belong to advanced dynamics."[1] To introduce and teach these fundamental concepts of electricity and magnetism presents certain problems. The following scheme is offered as an elementary treatment that may result in useful concepts of inductance and capacitance.

In a consideration of the nature of inductance and capacitance one should distinguish between the apparent inductance and the true inductance of a given solenoid. The true inductance is the value obtained by the use of the various inductance formulae, and approximately so, by measurements at a frequency considerably below the resonant frequency of the solenoid. Terman gives the following expression for the apparent inductance:[2]

$$\text{Apparent Inductance} = L\frac{C+C_0}{C}$$

where

C_0 = the distributed capacitance of the solenoid
C = capacitance used to tune the solenoid to a certain frequency at which the apparent inductance is desired
L = the true inductance

The apparent inductance is, therefore, the true inductance multiplied by a factor slightly greater than one (at frequencies where the distributed capacitance is small compared to the tuning or external capacitance). This factor increases as the ratio between the tuning or external capacitance to the distributed or internal capacitance decreases (which occurs as one tunes towards resonance).

To provide experimental results upon which to base further discussion, the following procedure is of interest. One must prepare three solenoids for measurements of inductance. To do so, first secure three equal lengths of wire (300 cm. lengths of No. 20 insulated copper bell wire are suitable). Next select a round coil form, a square coil form, and a flat coil form (in the latter the ratio of the width to the thickness can be about 8 to 1). Arrange to have the principal dimensions,

[1] S. A. Schelkunoff, "Guided Propagation." No. 4 of a consolidated reprint of lectures published in "Electrical Engineering" entitled "Ultrashort Electromagnetic Waves." American Institute of Electrical Engineers, 33 West 39th St., New York 18, N. Y., p. 31.

[2] F. E. Terman, J. M. Pettit, *Electronic Measurements*, McGraw-Hill Book Co., New York, N.Y., 1952, p. 89.

that is, the diameter, the side, and the width of the respective coil forms similar in magnitude (say, within plus or minus 0.5 cm.). For the length of wire suggested, about 3 cm. is a satisfactory principal dimension. The winding rate should be a maximum to give close-wound windings and the same for the three solenoids. The material for the coil forms should be an insulating material (well seasoned pine worked well, for this experimenter, with the square coil form).

When the winding is completed on each of the coil forms, one will have three solenoids which differ only in cross-section shape, i.e., the cross-section is the parameter that is allowed to vary.

Measurements of the apparent inductance at different radio frequencies should now be made for the three solenoids.[3] When these

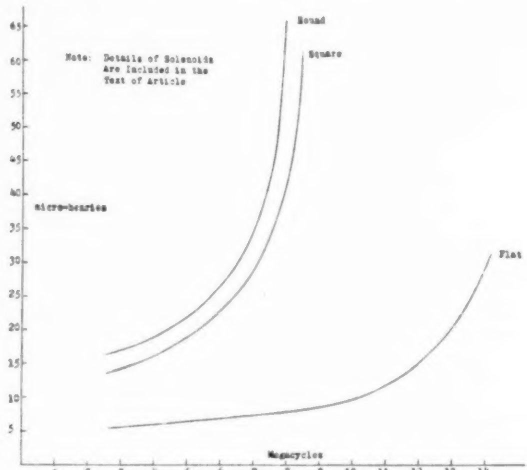

FIG. 1. Variation of apparent inductance with frequency; parameter: cross-section.

values of apparent inductance are plotted against frequency, and smooth curves drawn connecting the points, three curves will be evident. Figure 1 is an example of three such curves.

Inspection of the curves reveals that the solenoids have different initial values of apparent inductance, even though each is wound with the same length of wire. It can be noted that the flat solenoid has the greatest amount of initial distributed capacitance. The round solenoid has the least distributed capacitance, but the greatest initial

[3] For a circuit and suggestions for a method see: Norman R. Dilley, "An Electronic Bridge for Inductance and Capacitance Measurements," SCHOOL SCIENCE AND MATHEMATICS, June, 1955, p. 430.

apparent inductance. Naturally it reaches self-resonance first as its distributed capacitance is a minimum for the three solenoids.

It can be seen that the self-resonant frequency of the flat solenoid is considerably greater than that of the square or the round solenoid. This is the result of the relatively large amount of initial distributed capacitance "wound in" and the relatively small amount of initial apparent inductance of the flat solenoid (if solenoids may be called "flat").

Self-resonance indicates an equality of the inductive and capacitive reactances (actually a cancellation of the two reactances which leaves the impedance resistive). In the case of the flat solenoid, a considerable increase in frequency is necessary to bring about this equality because of the small initial inductance.

Consideration of the three curves reveals, that for a given solenoid, the apparent inductance is dependent upon the frequency and also upon the manner in which the copper wire is wound about the axis of the coil form. It is evident that the ratio of the distributed capacitance to the apparent inductance can be modified by a change in the cross-section shape of the coil form. In the present set of measurements, other intermediate curves would have resulted provided forms were used which had a width to thickness ratio of less than 8 to 1 (that of the flat solenoid). It is a problem for the radio engineer to design coils for a certain self-resonant frequency. This procedure can be a method.

A paradox can arise if one attempts to state that the value of the apparent inductance (of solenoids wound with equal lengths of wire) depends upon the value of the distributed capacitance. The reverse is also true. This indicates that a solenoid cannot be considered as an "inductance," but as a system where the inductance and capacitance are determined by the frequency of operation.

Inductance appears to result from arranging matter in a linear form (consider a wire). Capacitance appears to result from arranging matter in a planar form (consider the plates of a capacitor).

Some general statements concerning the solenoid as a physical system are possible. For instance, winding a given length of wire into a solenoid, to attain the greatest initial distributed capacitance, increases the ratio of the distributed capacitance to the apparent inductance. This procedure also maximizes the self-resonant frequency, but minimizes the Q (the ratio of the inductive reactance to the resistance). Winding the same length of wire to attain the smallest initial distributed capacitance decreases the ratio of the distributed capacitance to the apparent inductance. This procedure minimizes the self-resonant frequency, but maximizes the Q.

An analogy with the operation of a loudspeaker associated with

an audio amplifier can be pointed out here. If, for a given size of speaker, a second speaker of the same size but with a cone of material of relatively greater stiffness, is used, the self-resonant frequency will be increased. Evidently this is a case of the result of the addition of distributed capacitance to a system.

It can be noted that the round solenoid has the least distributed capacitance and the highest operating Q for the three solenoids. This follows when one recalls that the Q is inversely proportional to the distributed capacitance. On the question of possible bandwidth of operation, it can be seen that operation with maximum response (maximum Q) restricts the range of frequency. Operation with a minimum system response (minimum Q) extends or maximizes the operational bandwidth.

The functional or operational concept of inductance or capacitance is not apparent in the typical definitions of inductance.[4] These, in symbols, can be stated as:

$$e=-L\frac{di}{dt} \qquad 1$$

$$W=\tfrac{1}{2}Li^2 \qquad 2$$

$$L=\sum\frac{\phi T}{i} \qquad 3$$

where

e = the induced e.m.f.

L = the inductance

i = unit current

W = the energy

and

ϕT = total flux turns

The first expression illustrates how a voltage is generated across a solenoid and, while a very fundamental formula of electricity and magnetism, only indirectly implies the effect of frequency and that in reference to the generated voltage, not the inductance.

The second and the third formulae presume a static current and hence the inductance is not considered frequency dependent.

Where a functional concept of inductance is desired, William Thomson's formula for the resonant frequency is of value. This, in symbols certainly obvious to all students of physics, can be written as:

[4] P. Hammond, "The Calculation of Inductance." *Bulletin of Electrical Engineering Education*, College of Technology, Manchester, England, December, 1953, pp. 23–27.

$$LC\omega^2 = 1 \qquad 4$$

and, alternatively:

$$L = \frac{1}{4\pi^2 f^2 C}. \qquad 5$$

From inspection of equation five one can note that if the frequency is increased, the value of the capacitance must be decreased to maintain the resonant condition (with a given inductance). If one differentiates the function to secure the partial derivative of inductance with respect to frequency, one secures a negative quantity. This, if correct, would indicate a decrease in the value of inductance with frequency, a condition contrary to experience. Hence one must regard equation five as an equality of magnitudes, not of sign. Capacitance, making up the capacitance reactance, must be considered negative in respect to inductance (which is considered positive).

If one considers that the planar form, or matter exhibiting capacitance, is exactly opposite to matter in the linear form, which exhibits inductance, one can note the need for an exact opposition in sign. Linearity is infinitely removed from planarity.

The increase of apparent capacitance in the case of a well designed variable air capacitor is fairly constant with frequency. Self-resonance, possible with the usual small residual inductance present in the frame of the capacitor, would occur only at a relatively high frequency (several times that of the self resonant point of the solenoids mentioned in this paper). One manufacturer claims a relatively constant capacitance increase with frequency amounting to about 10% for a ten fold increase in frequency.[5] This was in connection with a well designed variable air capacitor.

Capacitive reactance varies inversely with frequency, while inductive reactance varies directly with frequency. Apparent inductance and apparent capacitance, however, both vary directly with frequency. Considering a solenoid as a system, then for operation over a certain frequency range, there is present, besides the true capacitance and the true inductance, an increase (with frequency) of both inductance and capacitance. The latter is due to the fact that the form of the solenoid and the capacitor does not change with frequency, hence the electrical characteristics of the two are modified (being representative forms of matter). One could state that the form of matter is frequency dependent and more exactly, one could say that matter is frequency dependent.

Frequency, being the reciprocal of the time of one period of a

[5] See the catalogue of the General Radio Co., Cambridge, Mass. (Section on variable air capacitors).

cycle, is fundamental. It is as time, usually an independent variable. Apparent inductance and apparent capacitance are then functions of frequency or time. To predict the self-resonant frequency of a given solenoid, one must take into consideration the two partial derivatives of inductance and capacitance with respect to frequency (resulting in apparent inductance and apparent capacitance). However, the actual physical form of both the solenoid and the capacitor can vary, even for given values of inductance and capacitance units. This factor affects the value of the partial derivatives, either positively or negatively. Hence the determination of the self-resonant frequency of a solenoid (or any physical system) will remain largely an empirical procedure.

There is yet another way in which some understanding of inductance and capacitance can be secured. Consider for a minute the fact that a solenoid, as far an arbitary method of symmetrically arranging matter into a certain form is concerned, is intermediate between two limits of form, the linear and the planar. A given length of wire can be either stretched out in an antenna like form, or it can be put into a concentrically wound "pancake." As the solenoid increases in either length or diameter or both (gaining area in either case), the self-resonant frequency decreases. At the limit of the processes of decreasing the resonant frequency and gaining area, the solenoid becomes a capacitance. In a sense, then, every solenoid is partly a capacitor and every capacitor is partly a solenoid.

With a given length of wire, the maximum frequency response occurs when the wire is entirely linear (as an antenna) or so arranged that as a system it has minimum self-capacitance. For instance, the length of wire used in the solenoids of this paper (300 cm.) when so arranged would have a self-resonant frequency of about 100 megacycles. Constrast this with the self-resonant frequency of 8 megacycles for the round solenoid. The total matter remains the same, but the manner in which it is arranged (that is, its form) is different. The self-inductance of the 100 megacycle resonant 300 cm. of No. 20 copper wire can be found from the following formula:[6]

$$L = 0.00508l\left(2.303 \log_{10} \frac{4l}{d} - 0.75\right) \mu\text{henries} \qquad 6$$

where

l = length in inches

and

d = diameter in inches.

[6] C-74, Circular of the Natl. Bureau of Standards, Supt. of Documents, Washington, D. C., p. 243.

This formula gives the true inductance for the 100 megacycle system. This calculates out to be very close to 5.30 μh. A system capacitance of about 0.55 $\mu\mu$f is indicated for this inductance (assuming resonance). The ratio of inductance to capacitance is about 9.64 to unity.

In the case of the 8.0 megacycle system (the round solenoid), if one takes the apparent inductance to be 65 μh, one has an indicated 6 $\mu\mu$f of system capacitance. The ratio of inductance to capacitance is about 10.8 to unity.

This illustrates how the form of a given amount of matter (a given length of wire) changes its electrical characteristics.

In a general sense, then, inductance and capacitance exist as a consequence of the interaction of matter on frequency or the form of matter on frequency. The electron, existing as a particle or as a wave, yet remaining a part of matter, determines if the matter will exhibit a capacitance effect, or an inductance effect to the observer and at the same time, to the universe. Inductance and capacitance are not fundamental quantities, but are characteristics of the form of matter and the frequency involved.

The electron can exist as a particle or a wave, or pass from one "state" to another and yet retain its identity, depending upon the presence or change in the ratio of the inductance and capacitance present in the system observed.

Considering energy, inductance and capacitance form "dimensions" in which energy can exist.

Recent discoveries of the physical mechanism of metallic current conduction may result in a more fundamental understanding of the nature of inductance and capacitance.

BUCKNELL PLANS A SCIENCE FAIR

Bucknell University will sponsor a science fair for students of the Susquehanna Valley area in April, it was announced today.

A group of area educators met at the university yesterday to discuss methods of conducting the fair. High school students in grades nine through 12 will be asked to prepare and enter exhibits.

Classifications the students may consider include physical sciences, astronomy, aviation, chemistry, electricity, electronics, engineering, geology, heat, light, magnetism, mathematics, mechanics, nuclear energy, and sound.

TRENDS IN THE TEACHING OF HIGH SCHOOL BIOLOGY*

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In a discussion of a similar nature two years ago, several items were mentioned as receiving special emphasis by biology teachers. These were general education, projects, local problems, audio-visual aids, new discoveries, ecology, and outdoor education. The cooperation of industry was noted, and it was observed that attention was being given to socialized procedures in the classroom.

Some of these items, as general education and ecology, were old ideas receiving renewed emphasis. Others were recent developments.

One really cannot analyze recent trends without exploring the teaching of the biological sciences of an earlier time. Let us look back to the early years of the century to see what was being offered in the secondary schools. Lloyd and Bigelow's book, *The Teaching of Biology*, published in 1904, reveals much information about the practices of the time.

"Biology" then consisted of separate courses in botany and zoology and sometimes physiology, each of these either a semester or a year in length. These offerings were frequently preceded by work in nature study and physiology in the elementary schools. The separate courses were spoken of as "biology" before there was any attempt at synthesis of subject matter.

We are all familiar with the purposes of the teaching of biology today. Were they any different fifty years ago? There certainly was a difference in emphasis. Lloyd[1] stressed (1) the pleasure value of biology—its contribution to the aesthetic side of life, (2) its value as discipline of the mind, and (3) its humanistic value, measured by the amount and value of the information it brings.

He was thinking particularly of botany which, he was sorry to note, had been largely a subject for girls up to that time. He felt that the dignity of the subject must be apparent to students. A course in botany should not be a "snap" but should make strenuous demands upon the students. It should do duty as "plain old-fashioned discipline." We certainly have abandoned most of this emphasis upon mental discipline.

Bigelow[2] also stressed the value of zoology as discipline. His other

* Presented at the Biology Section Meeting of the Central Association of Science and Mathematics Teachers' Friday, Nov. 25, 1955, Detroit, Mich.

[1] F. E. Lloyd and M. A. Bigelow, *The Teaching of Biology* (New York: Longmans, Green and Co., 1904), p. 24.

[2] *Ibid.*, p. 244.

aim in teaching zoology was to give information which would have utilitarian value as applied science, intellectual value as pure science, aesthetic value, and moral value.

Both authors stressed the importance of teaching the scientific method, but they thought of it as a discipline of the mind developed by rigorous study of science and the work of scientists. Today, we are more concerned with the development of desirable habits and attitudes through actual use of the scientific method in the solving of problems.

Many of us think of today's emphasis upon general education in the high schools as rather new. It is surprising to read the many references to general and liberal education in the "methods" book of 1904.

Lloyd certainly had the general education viewpoint when he said that botany in high school should be for the masses, and it should help produce intelligent and thoughtful citizens. He felt that it must be first planned for the average high school pupil and secondarily, for the candidate for college. Bigelow did not want to emphasize in zoology that which is important only to the specialist. He said, "The problem is to fill that one course with those zoological facts and ideas which have the closest relation to the everyday life of a liberally educated man."[3]

The high school biology teacher of today is concerned with both the "masses" and the more select group that will go to college. He wishes to prepare his students for college and often tries to do so by attempting to teach the same things that the student will later study in college. He may lose sight of the belief that many hold—namely, that the best preparation for college is a good general education.

Over fifty years ago, Bigelow stated that "—the work of the school should not come into serious conflict with that of the colleges."[4] In his day, as today, there were many teachers who were trying to inflict upon high school students everything the teachers had learned in college. They were using college textbooks and outlines in high school classes.

In 1898, Harvard University made the first clear distinction between high school and college courses in their "Outline of Requirements intended for use in preparing students for the Lawrence Scientific School."[5] Soon after that, texts and other teaching materials were developed specifically for use in the high schools.

Some teachers today pride themselves upon offering college-level work to high school students. This trespasses upon the rightful do-

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[3] *Ibid.*, p. 262.
[4] *Ibid.*, p. 451.
[5] *Ibid.*, p. 449.

main of the colleges and deprives the high school student of some portion of the general education program that should be his.

In 1934, Cole[6] ably stated the aims of general education. He stressed the common educational needs of students and believed that subject-matter should be omitted if it is not useful to a majority of the pupils. It is likely that the general education viewpoint has grown in prevalence with each passing year. It is commonly held today.

The Birth of Biology

Although a few high schools retain separate courses in botany, zoology, and possibly physiology, biology is found in the curriculum of 95 per cent of the public secondary schools today.[7]

At the beginning of the century, high school biology was non-existent, and there were no textbooks on the subject. A movement to introduce such a subject was underway, however. In 1904, Bigelow stated that biology was a unified science, and the division of the subject-matter into botany and zoology was largely arbitrary. He looked forward to the time when a unified course would make it unnecessary and undesirable to draw any line between the two.[8] He also believed that human physiology should be incorporated into the course. He felt that the sum total of biological science in the high school should not exceed one year. This, of course, is common practice today.

In 1901, a Northwestern University professor, W. S. Hall, laid the foundation for a type of biology common today. He advocated a synthesis of zoology and physiology into a "biology of man" which would follow a course in botany. He, however, was unwilling to go very far into the subject. "Questions of life history, reproduction, whence, how, and whither would better not be discussed. The courses in botany and zoology have sharpened the senses and incited the thoughtful questioning of the pupil. When he comes to the study of man, leave him alone with his thoughts on these deeper and more delicate questions, and he will arrive at the truth."[9]

Too many biology teachers have taken his cue and buried their heads in sand in the past half century.

Biology gradually became well established. Over a quarter of a century ago, I was a student in an excellent high school course in general biology. In 1934, Cole reported a tendency to combine

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[6] Wm. E. Cole, *The Teaching of Biology* (New York: Appleton-Century, 1934).

[7] W. Edgar Martin, *The Teaching of General Biology in the Public High Schools of the United States* (U. S. Office of Education, Bulletin 1952, No. 9), pp. 3–4.

[8] Lloyd and Bigelow, *op. cit.*, pp. 331–335.

[9] *Ibid.*, p. 460 and W. S. Hall, "The Presentation of Physiology to High School Classes," *School Science*, I. (1901), pp. 58–61.

botany and zoology. He also noted a recent trend to eliminate human physiology, as a separate subject, from the secondary curriculum and include it in a course in biology.

TODAY *versus* YESTERDAY

Let us briefly contrast certain aspects of today's biology with that of fifty years ago. Consider the matter of teleology, or purposeful behavior in organisms, especially plants. Teleological explanations were quite common in the older textbooks and even in the conversation of persons with considerable training in biology. I do not recall having become aware of teleology until I was a graduate student.

Nevertheless, Lloyd warned against the teleological interpretation of nature in 1904. It apparently was quite common at that time. Today we have great difficulty in finding such an explanation in a modern biology textbook.

We think of ecology as a new branch of biological science, and indeed, it has made great progress in the past twenty-five years. The "ecological viewpoint" has only lately become common among biology teachers. The basic principles have only recently been stressed in textbooks.

Nevertheless, in 1904, Lloyd was advocating ecology and recommending the experimental determination of the relation of an organism and its environment. Bigelow recommended that animal ecology be emphasized in all elementary courses.

There is not time to discuss the development of the teaching of biological evolution. We all know that at certain times and in certain places the subject has created a considerable furor. Bigelow favored teaching the facts of evolution, but not *advocating* it. In his day, the subject was avoided, no doubt, by most teachers. The inclusion of evolution in textbooks and courses is quite generally accepted today.

Sex education is frequently incorporated into biology and other courses in today's schools. It meets with little opposition. In fact, many parents urge its inclusion in the educational program. This was not always so. I remember well that my high school biology teacher, an excellent one, was dismissed for daring to teach the "facts of life and reproduction" to eager adolescents.

Lloyd and Bigelow gave lip service to sex instruction. The former called for sex education to supplement home training or to take its place when absent. It was his belief that the introduction to essential knowledge of generative processes could most appropriately and effectively be made in a course in botany. He advocated sneaking up on the students with a discussion of vegetative reproduction and then introducing the isogamy of *Spirogyra* and the heterogamy of higher plants. "The absence of highly specialized secondary sexual char-

acters makes it easy to avoid any pointed or suggestive discussion, while the main facts are sufficiently obvious."[10] What a daring pedagog he was!

Lloyd also felt that the biological aspect of the matter alone was all the teacher had to mention. His duty was then done. "For the rest we place our trust in the belief that right or pure ideas will assert themselves, and that the mind of the pupil will be the more frank and open to the exercise of moral living."[11]

Bigelow was no more brave. He believed in sex education and advocated the study of embryology and the facts of reproduction—up to the mammals, but it must stop there. He was in complete agreement with Professor Hall, who was quoted above as opposing any discussion of the life history or reproduction of man.

The biology textbooks of today are as devoid of discussion of human reproduction as if Lloyd and Bigelow had edited them. There are available, however, many fine audio-visual aids and printed materials which enlightened teachers can, and do, use. It seems, then, that inclusion of sex instruction and its general acceptance is definitely a recent trend in the teaching of biology.

Let us note one other contrast. In his study of high school biology courses in 1949–50, Martin discovered that 76.5 per cent of the courses were based upon fundamental principles. This was not true in an earlier day. Bigelow noted that biology in his day was concerned chiefly with the facts of classification, morphology, and physiology. He complained, ". . . we have yet to learn concentration of attention upon important and fundamental principles. . . ."[12]

Teaching Methods

The use of the laboratory has been traditional in the biological sciences. It seems that laboratory work was very prevalent in the early courses in botany and zoology. Bigelow said that laboratory exercises should be the basis of a course, and the textbook should be used to verify and supplement. He was disappointed, however, to detect a tendency to depend upon the text and to drift toward the recitation method. He criticized this trend which has become quite prevalent today. In many instances it is the main activity, and in some, the only method of instruction.

The early emphasis in laboratory work was upon observation and drawing. Lloyd warned against excessive drawing, but Bigelow considered it very important. He condoned—even suggested—the copying of drawing from books.

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[10] *Ibid.*, p. 79.
[11] *Ibid.*, p. 79.
[12] *Ibid.*, p. 334.

The author has at hand the laboratory notebook of a high school student in zoology in 1905. The first half of the work consists of extremely neat and elaborate drawings, done in ink, and obviously copied, because of their detail and complete labelling. We find such things as the "Internal Anatomy of a Calcareous Sponge," "Diagrammatic View of a Sea Anemone," "The Internal Anatomy of a Liver Fluke," and a "Diagrammatic View of the Soft Parts of an Oyster."

It is quite likely that the small Illinois high school where this work was done did not possess specimens of any of these organisms. The laboratory work consisted of copying from a text or other source. Its value is certainly doubtful.

In 1934, Cole criticized the use of detailed laboratory dissection and the making of drawings in high school biology. He felt that it was especially bad to require students to draw pictures of apparatus. He appropriately stated that although biology is the science of life, it has received the touch of death because of the faults of laboratory methods.

There seems to be a definite trend toward the elimination of most drawings on high school biology. It is still a controversial subject, but on the basis of experience the author favors the present tendency toward providing the students with outline drawings. These are labelled after examination of appropriate organisms, location of the parts in the specimens, and a discussion of the structures under the supervision of the teacher. Too many students have developed an aversion for biology and have received low grades because of inability to produce drawings that resembled the specimens!

New Content in Courses

What areas of subject matter are stressed today that seem to have been completely absent in the courses of fifty years ago? An examination of twenty recent textbooks for high school biology reveals that all of them include a chapter or unit on heredity. The science of genetics, of course, did not come into existence until 1900. It is now included in practically all courses in biology.

With one exception, the texts devoted considerable space to conservation. Conservation education has expanded rapidly in the past decade. There is now an overwhelming volume of teaching material available, and biology teachers everywhere are using it.

All of the books examined covered various aspects of health and disease. There is a new emphasis upon these topics, and some concepts are new, but the material is old. It has been transferred from the defunct courses in physiology and hygiene.

A majority of texts close with some mention of the role of biology in today's vocations and avocations. This is entirely appropriate, for there is a need to acquaint youth with the many vocational opportunities open in various scientific fields. This may assist in meeting the great demand for manpower in these areas.

The remainder of the subject matter in most texts is traditional. Much of it may be traced back to the early courses in botany and zoology.

Current Practices in High School biology

It is interesting and worthwhile to take note of the actual activities of the teachers in the biology classrooms of today. Some comments follow, based upon personal observations or first-hand reports of other observers.

First, attention will be given to poor or objectionable practices. In defense of some teachers, it must be said that they are forced to teach a wide variety of subjects even though their academic preparation in some is meager. Occasionally, undesirable situations are beyond the control of the teacher. Nevertheless, the following practices are in need of improvement.

In a number of schools, both large and small, we find no laboratory work. All instruction is by lecture, text reading, and recitation. Some schools have no biology laboratory and little equipment. Some have no models; others, no charts. Occasionally, teachers do not use those that they do have.

Often there are few microscopes, and in one case, they are present but not used. One teacher uses no prepared microscope slides "because students break them." No living plants or animals are found in some laboratories.

Some teachers, especially those in large schools, take no field trips. In one situation, teachers do not even take the classes outside the door when there is an extensive unit on plants. Excuses for no field trips include "against school policy," "I don't like field trips," and "there's no place to go."

Audio-visual aids are not used by some. One teacher is opposed; another has trouble getting them. A common fault of those who do use motion pictures is showing them out of context. Oftentimes the film is used merely to take up time.

One teacher uses no references of any kind, other than the text, because "students copy from them." At the other extreme, another permits students to copy workbook exercises from each other.

It is common for teachers to have poorly defined objectives, or possibly none at all. In other cases, the main objective is to prepare

for college, even though only a small percentage of the students ever enter college.

One teacher complains that students are not interested in biology, while another says only the poor students take it. These conditions possibly are the result of poor teaching, while this in turn is the outcome of poor or inadequate preparation.

Now let us look at the favorable aspects of current teaching. Capable, inspiring, well-educated teachers seem to be in the majority. They do superior teaching as a routine. The following are some of the commendable practices observed.

In the classrooms and laboratories are found numerous reference books, pamphlets, and periodicals which receive frequent use. Skillful use is made of good collections of teaching aids, such as charts and models. A variety of projected audio-visual aids are blended into the course work.

Students care for terraria, aquaria, bee hives, cages of live animals and arrays of growing plants in classrooms and greenhouses. There may even be a school garden, nursery, or forest.

Field trips are used when appropriate. A trip is often taken on the school grounds or to a nearby lot, park, woods, field, or stream during the regular class hour. Special extracurricular trips are arranged on Saturdays to more distant places of interest, such as conservatories, dunes, forests, museums, and zoos.

Student projects are much in evidence. The better ones are exhibited at science fairs and the school openhouse. Biology clubs are active in carrying out group projects of various kinds.

The classroom and storeroom cases and shelves are stocked with student-made equipment and student-collected materials. These are used in the daily work of the classes.

There is certainly a keen interest in the subject in most schools. The biology teachers are making an important contribution to the education for life. And frequently, it is the biology teacher who lights the first spark of interest in the potential drop-out, and who eventually salvages him.

These same teachers are the ones who are doing much today to discover and develop scientific talent in the youth who will become the scientists of tomorrow.

We should not overlook the fact that large numbers of our teachers today join and participate in the activities of the various professional organizations for science teachers. They read the journals that come to their desks, and many are contributing articles to these journals.

Biology is the science of life. This is very evident as one walks into the modern high school biology room. It is literally alive. Adolescents

are surrounded by a variety of living organisms, and an alert teacher is directing the activity.

This, then, is the outstanding trend in the teaching of high school biology today—it is becoming a *living* subject.

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COLLEGES COOPERATE IN TRAINING SCIENTISTS

Brandeis University and Carnegie Institute of Technology will cooperate in a five year educational program leading to both liberal arts and engineering or science degrees.

Announcement of the cooperative programs, known as the 3-2 plan, was made jointly by President A. L. Sachar of Brandeis University and Carnegie President, J. C. Warner.

In the Plan, students will take three years of liberal arts with a major in science at Brandeis University, then transfer to Carnegie Tech for two years of engineering or science. At the end of five years, they will receive bachelor of arts degrees from Brandeis and bachelor of science degrees from Carnegie.

Transfer 3-2 students from Brandeis will be able to study one of Carnegie's three pure science curriculums: chemistry, physics, or mathematics, or may choose one of the five engineering departments: civil, electrical, mechanical, chemical or metallurgical. They may also enter the Department of Industrial Management.

Brandeis University is the twenty-third liberal arts college to join with Carnegie in the 3-2 program.

This plan, according to Carnegie officials, allows the student a broad liberal arts foundation before he undertakes a technical program. It also gives the undecided student some college experience which helps him choose whether he really wants to study engineering or science.

"Because of these advantages," Carnegie's President Warner said, "we have invited selected liberal arts colleges to join with us and we are indeed happy to welcome into the 3-2 Plan so fine an institution as Brandeis University."

In Waltham, Massachusetts, the seat of Brandeis University, President Sachar said, "It is a privilege for our young University to be linked academically with Carnegie Tech. The principle is sound that our specialists must have their roots in the humanist tradition of the western world. Such training will make them better men."

Brandeis University, which was established in 1948, includes a College of Liberal Arts and a Graduate School of Arts and Sciences. The undergraduate liberal arts college utilizes a general education approach to the liberal arts with students taking required courses the first two years and specializing in their last two years. The Graduate School of Arts and Sciences offers courses of study leading to the doctor's degree in seven areas.

Carnegie Tech, one of the nation's outstanding professional schools, includes a College of Engineering and Science. A College of Fine Arts, the Margaret Morrison Carnegie College, a Graduate School of Industrial Administration and a School of Printing Management.

THE GOAL IS MATHEMATICS FOR ALL*

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INTRODUCTION

The goal is mathematics for all, but certainly not the same mathematics nor the same amount of mathematics for all students. What follows is predicated on the thesis that all high school students are different; they are different in their physical and social maturity; they are different in their interests, desires, and needs; and most important for our consideration they are different in their mental capacity for learning mathematics. Furthermore, while all students grow in mental ability from year to year, they grow at very different rates. The only manner in which our students are alike is as human beings in their individual dignity. We respect this equality of human dignity. And if we do, we shall recognize and honor this dignity by providing differentiated educational programs compatible with the possibilities the students show. Any secondary school program based on a great leveling or evening of mankind by providing only one universal educational program is doomed to failure, because of the very great variation in ability that is the nature of human beings.

On the contrary, a program based on individual excellence, on the opportunity of each individual to excel to his highest capacity has great promise of successfully meeting American democratic ideals. How to accomplish this, especially in the field of mathematics, is as yet an unsolved problem, but there are many hopeful signs and certain emerging practices and theories that give promise of some realization of this goal. The School and College program for Admission with Advanced Standing, and the General Education in School and College Study are excellent examples of finding a mathematics program for the most able students. The experimental program at the University of Illinois will have force in changing a college preparatory program from a traditional to a modern one both in spirit and content. The increasing number of the less able students taking non-academic courses in mathematics and the appearance of more and better textbooks for these students is having a beneficial effect both on students' attitude toward and understanding of mathematics. These, and other practices are giving us a workable set of criteria for establishing a program in mathematics education for all.

Today I wish to give some of these criteria. Then, we can test them in the light of what mathematics is conceived to be in the year 1955.

* Presented at the General Program of the Central Association of Science and Mathematics Teachers at Detroit, Friday, November 25, 1955.

This should give us some sound reasons for the study of mathematics by all high school students. We can then close by giving some pertinent implications for mathematics teaching in the next few years ahead.

Criteria for Operating a Mathematics Program for All

The essential liberal or general mathematics education that should be common to all must be agreed upon. But this does not mean that only this mathematics should be taught, nor does it mean that all must acquire this common knowledge at the same time, in the same way, or to the same degree. What it does mean is:

1. *Each student should be allowed and encouraged to study and learn mathematics according to his intellectual ability to do so.* This means that we must offer a challenging program to our more able students. Many of these students today, are not doing as well as they can because we do not demand it of them, and we do not offer them a sufficiently rigorous program in mathematics.

In 1893, the N.E.A. Committee of Ten recommended that all high school students study the four years of traditional high school mathematics because of its power to train the mind. When 30 to 50 percent of the students failed in their study of mathematics we can well question what mind training actually took place. Knowing what we do today of the range in capacity to learn abstract reasoning, we say:

2. *No student should be forced into a course of study where the expected standard of performance is higher than he is mentally capable of attaining.* We have no right to expect the impossible of any person. But we do have a right to expect that all persons will do their best. If we do expect this then we must urge that:

3. *Every school should provide a multiple four year program (years 9 to 12) in mathematics for all students with group provisions in each year of study.* This means that flexible curricula and flexible teaching procedures must be available and adapted year after year to the various groups of abilities that exist and will continue to exist in the high school. We do not raise the question, in this day, of how much mathematics a particular person will need or will use. Any individual can use all the mathematical knowledge he is capable of learning. The real question is can a student learn the mathematics for which there is so great a need and use today.

In order to operate an adaptive program with effectiveness, teachers must quickly learn to know their students. This is necessary since:

4. *A mathematics program will succeed only if students succeed in learning a challenging subject matter content.* This means we cannot be mere lectureres or presenters of our subject, but we must become

master teachers. We must train ourselves as observers of students' characteristics so that we allow no student who is capable to slip into a cinch, no work program, nor allow a hard plodding worker to succumb to an impossible task. We must measure accurately and then challenge our students' abilities to the utmost.

In teaching the slower learner, we are so apt to resort to little bits of learning, to isolated unrelated chapters, to manipulations and fact. This is a questionable procedure, for if mathematics is to operate in the life affairs of any individual, then for all students, bright or dull, fast or slow,

5. *Mathematics is an organized structure of related knowledge, not a myriad of facts and skills.* This calls for a continuing process of study wherein mathematics is conceived as a whole. The process is at a pace that is fast for some students and a slow walk for others, but nevertheless it goes along the same path. Some repetition is necessary at times, but the mathematics programs of today are extremely wasteful of time and effort in the duplication, triplication, and even nth-lication of educational experience. A second track was not intended to be a shuttle line, but a slower trunk line.

In teaching an organized structure, skills in manipulation are secondary to concepts and understanding. Thus the idea of proof, symbol, variable, function, solution, etc. are developed from experiences or instances in which the concept occurs. In developing these concepts, we exercise thinking more than we practice on skills. But:

6. *Concepts and skills are equally important and both necessary for the proper acquisition of mathematical knowledge.* The concepts enable us to interpret the universe in mathematical terms. The skills enable us to perform necessary operations to obtain solutions to our problems.

If we base a program of mathematics education on these criteria, then we must also know the content or structure of mathematics that we will teach. Mathematics, as in the case of all other useful subjects, has increased its store of knowledge tremedously within the last fifty years. With the change in knowledge, there also comes a change in our conception of what mathematics is and does.

What Is Mathematics?

What is the mathematics that we teach in our schools? It has, in the past, been looked upon as a tool subject. Arithmetic was a tool for carrying out necessary computations. Algebra was a tool for carrying out operations on general numbers. Geometry was a tool for proving relations about figures in space. All this mathematics was a tool for learning the operations to be performed later in trigonometry and calculus. Because mathematics was looked upon solely as a tool, teaching it became a game of drilling in manipulations. Even today

in many places—perhaps the majority of places—arithmetic is learned by rote whereby the symbols are manipulated according to rule. There is no effort to show why the manipulations work. Today, algebra is taught almost totally as a tool subject in which meaningless symbols are manipulated to the nth degree. Geometry is to a great extent an elaboration of useless exercises and proofs of theorems.

We grant that in part mathematics is a tool subject, but we know that the meaningless manipulation of a tool has little value and no permanence in learning. Some students who made good grades in high school mathematics have difficulty with this subject in college. Because mathematics skills did not transfer to other problem situations, a number of years ago a new movement took place to teach mathematics as a social and practical instrument instead of a tool. Mathematics was to be learned in real life situations when and where it was needed to solve problems; in other words, incidentally or as isolated bits of procedures and manipulations necessary to solve quantitative problems in other areas of study. This concept is still present (and, unfortunately, accepted) in some core programs.

It did not take very long to discover that mathematics as a myriad of isolated facts to be used in various social situations was utterly unrealistic. Not only was there no transfer of learning but there was no mathematics. Without structure and organization, the limitless facts overwhelm even a superior mind. Social utility is of course a desirable aspect of mathematics, but it is not mathematics.

The failure of both the tool and the social utility concept of mathematics gave rise to a broader way of considering the subject. Mathematics became "a way of thinking," and mathematics concepts became the foundation for our teaching. Thus, 5+4 as a tool is merely 9 and nothing else. As a "way of thinking," 5+4 is a combining of two groups of elements into a single group. Similarly, all the other operations in arithmetic are developed first as concepts through "thinking" about what we do to groups of things. Then we develop symbolic processes to enable us to carry out our thinking in terms of particular groups of these things. These symbolic processes become our facts, our tables, and our computational algorisms. Thus, arithmetic has a why and a how, a concept and a manipulation, a thinking and a doing—*but fundamentally the arithmetic is the totality of related concepts; the way we think about number*. The symbolic processes are the recording and manipulating of our thinking. Mathematics as a way of thinking lies beyond and above the various social situations in which it is used.

Algebra is also a way of thinking about generalized relations in number systems, about variables and functions, and it is the way of

thinking that is of vital importance in understanding higher mathematics and applied mathematics. We are moving in this direction in the teaching of high school algebra, but we have taken only the first few steps. In too much of our teaching $3a+2a$ is still 3 apples and 2 apples (a silly and fallacious idea, since apples are not numbers) and it is not 3 multiplying a variable a plus 2 multiplying the same variable a. Similarly $(a-b)$ $(a-b)$ has a $+b^2$ in the expanded product with the reason given that "a negative times a negative is a positive" —a reason which has no application whatsoever in this case. We have not given enough consideration to the study of the "why" of algebra, and because we have not we shall continue to have poor educational outcomes. Until algebra becomes a way of thinking—a generalized arithmetic—out of which we develop the usual processes and manipulations for expediting our thinking, little value will result from its study.

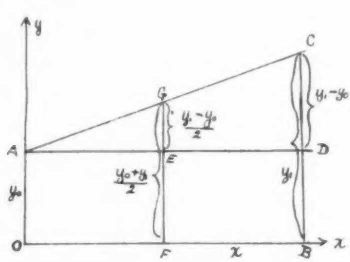
Geometry as a way of thinking has fared much better than algebra because of studies by Fawcett, Lazar, Ulmer, Ullsvik, and Gadske in applying goemetrical methods to everyday life situations. These investigators were interested in logic as a method of proof, as a means of using evidence to arrive at sound, tenable conclusions. However, some advocates, making the same error that produced the social utility idea in arithmetic, tried to apply the methods of geometry which are the methods of any mathematical discipline, to every life situation. What was called clear thinking through the study of geometry became befuddled thinking through the rejection of geometry. There is a healthy movement to return to "geometry as a way of thinking about spatial relations." Geometry has a particular structure, with fundamental concepts and logic. The rules of geometry are the tools (very important in using the subject), but the concepts of definition, undefined term, postulate, theorem, given data, conclusion, implication, and deduction are even more important than the rules, for it is a set of proper concepts that enables us to understand what we are doing. Mathematics as "a way of thinking" about numbers, variables, and space promises a more fruitful and more permanent learning experience for students.

Since mathematics as a way of thinking is applicable to varied situations, and acts as a guide for organization of knowledge in other fields, it must possess a structure that makes it independent of the situation or of other knowledge. "Mathematics is both queen and servant of the sciences." To serve in both capacities it must be learned as a well-organized hierarchy of concepts, relations, and operations; that is, as a self-contained structure. It is the thorough understanding of this structure that permits its correct application in solving our quantitative problems. It is this structure, also, that makes it the

main agent for communicating scientific thought, one of the most necessary functions of modern society.

Purposes of the Learning of Mathematics

There are at least five fundamental purposes that the study of mathematics should attain. First, it should serve as a functional tool in solving our individual everyday problems. The questions How much? How many? What form or shape? and Can you prove it? arise every day in the lives of every citizen. People who can answer these questions with ease and accuracy are happy. Those who cannot, make serious blunders and are frequently unhappy. To many people, effective citizenship and democratic action seem far removed from the effective use of basic mathematical concepts and skills. But if an effective citizen is one who earns his own living, rears and supports a family, buys and maintains his own house as a home, protects his family by adequate insurance, protects his job or career by proper investments, protects his old age by savings and annuities, figures and pays all his taxes honestly, with due regard to every allowable deduction, estimates and budgets his income, keeps himself informed of government finance and statistical surveys of the nation's economy, reads and interprets the business and financial section of the daily newspaper, serves in the armed forces or in the various areas for protection and preservation of our way of life, and makes thoughtful deductive analyses of a quantitative situation the predecessor and guide for his actions, then certainly efficient use of mathematics skills and concepts is very basic of democratic citizenship. It is in these life situations, or simulated situations, that the learning of mathematics is first motivated.



In the second place, mathematics serves as a handmaiden for the explanation of the quantitative situations in other subjects, such as economics, physics, navigation, finance, biology, and even the arts. The mathematics used in these areas of practice is exactly the same mathematics and involves the same mathematical concepts and

skills. It is only the things to which the mathematics is applied that are different, and this is immaterial if one really understands the mathematics. This service of mathematics is exceedingly important to future scientists, engineers, technologists, technicians, and skilled mechanics. It is a vocational or career service that is of value to large numbers of our present students.

To illustrate, in mathematics we have the concept of an area generated by a moving ordinate. We may have a situation, where the ordinate increases at a given rate, over the interval OB. We say the average ordinate is the average of the initial and final ordinate and if K is the area

$$K = x \cdot \bar{y} = x \cdot \frac{y_0 - y_1}{2} .$$

We also say the rate of increase of the ordinate is the slope of the line and write

$$m = \frac{y_1 - y_0}{x} .$$

In physics we also have a system of distances, velocities, and accelerations. If a body is moving at a velocity which is increasing at a constant rate, we say

$$s = \bar{v}t; \qquad a = \frac{v_1 - v_0}{t} . \qquad \bar{v} = \frac{v_0 + v_1}{2} .$$

We can now make an isomorphism between the physical system and the mathematical system. Let the area K be associated with the distance s; the ordinate y, with the velocity at any time t, the distance along the x-axis x, with time, t. Then the acceleration corresponds to the slope of the line AC. Thus the geometrical configuration becomes a model for *explaining* the physical system.

In the third place, mathematics, when properly conceived, becomes a procedure for thinking, for developing scientific structure, for drawing conclusions, and for solving problems. Its postulational nature, that is, accepted relations (axioms or postulates), undefined terms, definitions, theorems, and a logic, aids all other areas of knowledge to approach scientific perfection. This same structure aids us in problem-solving methods in which we collect, organize, and analyze data, and deduce conclusions for future action. For example, one who understands the mathematical method can easily frame the problem, Which is the better financially, to borrow $400 from the bank at 4% for a period of one month, or take it from my savings account paying 2%, whereby I lose the interest on the $400 for six

months? into a chain of syllogisms that leads to the correct response.

In the fourth place, mathematics is the best describer of the universe about us. In an age that has become statistical and scientific in much of its human endeavor, the need for people to understand these phenomena is not only a cultural necessity but to some extent a necessity for intelligent action. If the mathematics of international banking cannot in some way be made understandable to the layman, how can he determine his position in voting on such matters? If the forces of nuclear fission cannot be made quantitatively significant, how can the non-scientist determine his reactions to it other than to dread it? Mathematics communicates quantitative aspects of our society and our world in such simple statements as "the bacteria grow at a rate proportional to the number of them present," and in such a simple (?) symbolic relation as $E=mc^2$. A knowledge of mathematics enables the layman to interpret these statements. We need to refer again and again and translate into action the statement in the 1923 report on The Reorganization of Mathematics in Secondary Education, which reads:

> The primary purposes of the teaching of mathematics should be to develop those powers of understanding and of analyzing relations of quantity and of space which are necessary to an insight into a control over our environment, and to an appreciation of the progress of civilization in its various aspects; and to develop those habits of thought and of action which will make those powers effective in the life of the individual.

Fifthly, there is value in knowledge for its own sake. To come to know mathematics is to be at home in a realm of the greatest creation of the human mind. It gives its possessor a feeling of accomplishment altogether charming and satisfying. It enables him to really know the potentialities of the human mind and to seek values other than mere material gain. The beauty of mathematical structures and proofs give aesthetic satisfactions that are more enduring and of greater glory than any of the other purposes of acquiring knowledge. There is tremendous personal satisfaction and value in knowledge for knowledge's own sake.

Some New Horizons

The preceding discussion gives indication of a reorientation in mathematics education. We repeat, changes are now appearing in both teaching procedures and subject matter content that promise a richer and more enduring learning experience. The more important of these emerging practices seem to be the following:

1. Learning and thinking are synonymous and primary. The classroom is becoming a laboratory in which we work with concepts. The class is practicing thinking much more than drilling on skills. All

learning is looked upon as problem solving. Thus, finding 15% of 80 is now a problem, and a pupil does as much thinking in analyzing what is meant by and how to achieve the answer to this statement as he would to the question, How much do I save if I buy an article priced at $80 at a 15% discount? Similarly, in algebra he uses the graph of a relation to discover what it means to solve an equation. More emphasis is put on what is a root of an equation than on the mechanical solution of an equation. The mechanics are not neglected, but they are the end by-product, and not the main goal of learning. We are teaching students *to learn how to learn mathematics.*

2. Statistical reasoning is fast becoming an integral part of the common activities of man. It enters into the understanding and the explanation of problems in safety, genetics, longevity, human variability, cost of living, occupational choice, income distribution, advertising, age distribution, change in family size, testing, measuring, public opinion on public affairs, games of chance, sports, consumer preferences, scientific investigation, conservation, and many other areas that affect each one of us. For the interpretation of these areas there is not so much a need for the numerical computation of statistics such as the mean, median, mode, correlation, or variance as there is for knowing what these concepts imply. It is in the correct interpretation of presented statistics that the layman can take intelligent action.

The two important aspects of statistics for the citizen are: (1) in a distribution of attributes arising from chance causes there is a coexistence of stability (a central tendency) accompanied by a variation; and (2) by proper sampling, both the stability and the variation of the whole population can be predicted to a high degree of probability. Since the solution of group problems in a democratic society demands mass participation, and since the processes of solution often entail the use of statistical reasoning, the participation is possible only if large numbers of people are prepared to make the statistical approach. The mathematics classrooms are beginning to meet this challenge. Students are collecting, organizing, and analyzing statistical data. They are applying mathematical methods to the concepts of stability, variability, and sampling. For example, if the weights of all fourteen-year-old boys in a school are plotted in a distribution, and the average weight is 124 pounds with a standard deviation of 7 pounds, is a boy weighing 138 pounds overweight? A correct concept of variability in chance causes will indicate to future parents that overweight for an individual is a phenomenon that has nothing to do with the average weight of all individuals. When all facts are considered, the boy may actually be underweight. Parents who insist that their children who are under the average weight for their age

should gorge themselves with fat-producing foods are in dire need of mathematical statistical reasoning.

3. Laboratory procedures in which physical objects are counted, measured, subjected to transformations, and built to scale are being employed in the modern classroom. All mathematics learning can ultimately be traced back to some sensory experience, even though at times the chain may be long and nebulous. Recognizing this, the arithmetic classroom has representative materials for developing concepts—abaci, discs on magnetized boards, flannel boards, circles divided into fractional parts, and many other visual-tactile aids. The geometry classroom has adjustable triangles, quadrilaterals, regular and semi-regular solids, all of which can be investigated by measuring devices to discover relationships which are later proved deductively. More and more the need for films that can display the dynamic aspects of continuity and limits is being sensed. Mathematics is not a laboratory subject, it is a deductive abstract science. But its initial learning beings with things. The classrooms in mathematics are being equipped with things, and the teacher's great task is to advance the pupil from using sensory things to thinking in abstract symbols.

4. The non-academic learner has never fared well in his mathematics learning. The work in the classroom from the first grade on was usually geared to the better students. So the below normal and slow learner never did learn, and came to high school not knowing, even the fundamentals of arithmetic. A dual education program in high school mathematics is fast appearing. The courses are being adapted to the learner, and not the learner to prescribed courses impossible of his attainment. In the high school we are learning to reteach meaningful arithmetic, the type so urgently needed in citizenship and vocational life, to those who need it most. In the senior high school a course in consumer mathematics is beginning to meet the needs of young women and men who will within a short time be mothers and fathers, soldiers and workers, and voting citizens. But the knowledge in these courses must be organized into a better hierarchy of learning.

5. The mathematically gifted child has been one of the most neglected in the past twenty years, when the great influx of all youth of high school age caused a lowering of academic requirements for all high school graduates. The growing scarcity of scientific, engineering, and mathematics personnel in the United States has instigated a search for these people, and with the search an attempt to provide an adequate educational program for them. In the professional literature, programs are now being proposed for these students, and in the near future we can see them doing all the usual first one or two years

of collegiate mathematics before they complete their high school term. They, by their very ability, will deal more with pure mathematics, in abstractions, and will need little of sensory experience to guide them.

6. Historical approaches to learning mathematics have been rarely used in school classes. Yet the growth of mankind is largely reflected in the growth and development of mathematical concepts. Since a concept is not just one thing, but an ever-growing, deepening, widening phenomenon, a student can learn to discover, learn to create, by studying the discovery and creation of the present concepts taught in school mathematics. To study number as the Babylonians, the Egyptians, the Greeks, the Romans, the Arabs, and finally the modern western world came to conceive of number is to build a real understanding of modern arithmetic. To study algebra from the rhetorical stage through the syncopated stage that was used by Diophantus to the modern symbolic state is to develop a deeper concept of symbolic thinking. To study Euclid's geometry, then analytic geometry, is to develop an appreciation of the power of algebraic methods for the solution of space problems. Not all concepts in mathematics should be treated historically. But as an indestructible yet growing instrument for interpreting our modern world, mathematics is being taught by teachers today more and more through its historical development.

7. Contemporary mathematics and mathematical thought will reshape much of the content and goals in our present high school programs. The ideas, elements, and symbolism of set theory will and must become a part of our algebra instruction. The concept of variable and function will be more rigorous and quite different from that currently appearing in our high school textbooks. Axiomatics and the nature of mathematical proof will not only change our goals in teaching geometry from mere elaboration of deducibility, to a deeper investigation of what mathematics, is, but this will also become more evident in our teaching of algebra and advanced mathematics. More than ever before, concepts, meanings, and understandings will be topmost in preparing our students for further mathematical study, rather than drill and manipulations on incomprehensible or even misunderstood operations.

In particular, solid geometry, as a course of continued elaboration of deducing theorems, will disappear from the curriculum. Much of plane geometry will be replaced by an analytic geometry, achieved by introducing the real number system and the correspondence of numbers with points in a plane. In algebra, we shall discuss sets and subsets of numbers, operations possible within the various sets of

numbers; generalized laws as verifiable statements. The logarithmic solution of triangles can disappear altogether, and the trigonometric functions will be related to number as well as to angles. It may well be that trigonometry, analytic geometry, and advanced algebra will disappear as separate subjects, and will be merged into one organized structure of study as mathematics or mathematical analysis.

By the eliminations of no longer useful mathematics, and by the reorientation of our teaching of algebra and geometry, we shall gain time and place to introduce the newer and more powerful concepts and skills of contemporary mathematics, and thus create a program consistent with our present culture and equal or better than that of any other secondary school program in the world. While this program may be for the college preparatory or more able high school students, we shall also introduce many of these modern concepts into the other high school courses of mathematics, because the newer mathematics is more powerful, more interesting and not more difficult than that mathematics now being taught; and it is designed for the solution of problems of our modern culture. It is universal mathematics, a mathematics for all.

MATHEMATICS BOOMING AT DARTMOUTH

More Dartmouth College students are studying mathematics today than ever before in the history of the college. Enrollments in both elementary and advanced math courses are at new high levels, and Prof. John G. Kemeny, department chairman, reports there is every indication that the figures will continue to rise.

"More than 95% of the freshmen this year are taking college mathematics," Professor Kemeny said. What's more, he reports that enrollment in advanced courses also is way up. Three reasons are given by Professor Kemeny for this tremendous interest in mathematics.

"The better college students almost always take some mathematics, often through calculus and into higher mathematics," he says, "and the plain fact is that college undergraduates today are better students than they used to be."

Greater and greater opportunities are opening up for mathematicians, Professor Kemeny reports, as the nation moves through the dawning of atomic power and automatic factories. "In the computing field, and in industry and government," he says, "there are needs for mathematicians today that were undreamed of a decade ago."

He says that students throughout the country are beginning to realize this, and the result is a significant increase in enrollment in math courses.

The third reason, particularly for Dartmouth's increase in mathematics students, is the establishment of an extremely successful honors program that starts with the gifted student's first day in the classroom.

Playground Map permits youngsters to walk from Boston to San Francisco. A map of the U. S. scaled one foot to 100 miles can be permanently laid out on a backyard or playground blacktop. The geography kit includes paint, supplies and a learn-by-doing booklet.

CHILDREN'S MUSEUMS IN SCIENCE EDUCATION*

MARGARET M. BRAYTON
Director, The Children's Museum, Detroit Public Schools, Detroit, Mich.

Last year (1954) in New York, the combined attendance at museums exceeded the combined attendance of the major baseball leagues in that city. This astounding fact reflects the public interest in the patronage of large and small museums all over the country. Travel-hungry Americans on the move put museums high on their sight-seeing lists. But this increase in tourists is not the only factor to account for growing attendance. Pressure on museums to share in meeting the national emergency in education is felt daily wherever there are collections, galleries, and visiting hours.

Add to these facts the impelling necessity for supremacy in science in the global struggle for survival, and the responsibility of teachers in schools, colleges, universities, and museums, staggers the imagination. At all levels, students need the best and the most that can be provided in this curriculum.

What then, is the role of children's museums in science education?

The first children's museum founded at Brooklyn, New York in 1899, gave immediate priority to the most popular collections called for by the children who thronged in after school and on Saturdays. Cases stored with animals, minerals, botanical models, shells, and fossils were in greatest demand. As a child pointed to a specimen, the curator opened the case and put the object into his hand while a group crowded around for the questions and answers. It was but a step to orderly classification by rooms and exhibits, to the grouping of children with like interests into clubs, to giving school classes "walk-talks" and to boxing duplicate collections into loans for teachers.

Fun with a purpose was the keynote of the program. In fact so serious were the children that a small reference library was added. Credit courses for membership in the Brookyn Children's Museum League reflected the philosophy of science education of that period. Among the most popular were those in bird, insect, aquarium, mineral, and botany study with emphasis on systematic classification, bibliography, composition, and technical illustration. All courses provided for the child's choice, ability, and work with the museum collections. All were geared to individual progress.

A mineral laboratory attracted for many years boys who gave evidence of the special qualifications needed for advanced study. Known as The Pick and Hammer Club, the membership was exclu-

* Presented to the General Science Section of the Central Association of Science and Mathematics Teachers, Detroit, Michigan, November 25, 1955.

sive in the intellectual sense and many of its numbers became engineers of the first order.

Boston, Detroit, Indianapolis followed with children's museums in the next twenty-five years. Their programs were based on the philosophy of giving the individual every opportunity to work with the collections he liked best. Encouragement of individual inquiry, study, and personal achievement characterized the development of the program. Needs of local schools, interests of the community, limitations of physical facilities have modified the emphasis but the over-all pattern runs true.

Children's museums have been pioneers in many fields of science education. Along with nature study grew microscopy. In 1932 the staff of the Brooklyn Children's Museum assisted CBS in experiments with television. In Boston daily field trips to the nearby Fenway were incorporated into the program in 1914. Soon these trips were expanded to longer excursions to Greater Boston. Today over 600 children in small groups known as the July Jaunters explore, collect, study, and report on trips made in series arranged around such interests as bird-watching, insects, marine biology. The Indianapolis Children's Museum has pioneered in work with the blind and other handicapped children by using its collections especially in the field of natural history.

More recently pioneering has included exhibits on light and color, the telephone, the weather, and aviation. Demonstrations of physical principles have been set up so that children may operate them to see for themselves. Since World War II, youth in many children's museums are studying astronomy and gaining concepts of the universe from planetariums installed for their knowledge and wonder. Implications for physics and chemistry must also be noted.

In Detroit, the Board of Education has full responsibility for the Children's Museum, its collections, activities, personnel, housing, and program. The docent lessons at the Museum and the loans to schools are the main divisions of the work in science education. Modern school buildings with well-equipped science rooms provide facilities for direct experiences in this field which preclude duplication by the Museum. Homerooms where science is taught, however, make heavy demands on the lending department. The Museum keeps close touch with science education through a committee of science advisors composed of teachers and the supervisor of science education in the elementary schools. Materials needed to supplement those in the science classrooms, themes for docent lessons at the Museum, talent among teachers for the monthly Saturday program on science, and current trends in the curriculum are subjects on which these advisors give invaluable aid. In turn, the Museum has a

chance to pose some of its problems, show its resources in unfamiliar areas, and keep a realistic approach to school-museum relations.

Today there are over sixty children's museums in addition to departments in other museums which provide a program for children. All of them work with schools although some are more recreational in their approach than those mentioned. Some serve areas where no other museum exists. Many serve a county, even a state. Hospitals, churches, adult groups, community agencies use the facilities as well as schools and individual children. Most of them receive grants in aid from boards of education but they are privately organized and financed.

Slides from a number of these institutions will illustrate some of the activities and characteristics mentioned. The museums were selected on the basis of their length of experience, their geographical location, and the special area of science in which they have developed a strong program. A brief glimpse of typical exhibits and collections which are lent to Detroit Public Schools will follow the showing of the slides.

What then, are some of the possible services to science teachers by children's museums?

1. The museum has unique materials to help children understand the world in which they live. Docent lessons or loans for classrooms are available from these stores.
2. The museum has resources and the staff are usually crusaders in challenging precocious children. In this present swing of attention to "gifted" children, the museum has an opportunity to help teachers.
3. The slow learner often finds at the museum a motivating experience when he comes with a class, joins a club, or attends programs on Saturdays.
4. Pride in personal achievement and in belonging to a group which took him in "on his own" and not because he had to report to school, is a common characteristic of regular museum visitors.
5. The museum values opportunities to work with teachers in committees devoted to solving mutual problems.
6. The museum welcomes requests from individual teachers for assistance on technical or other related problems.

It is evident from these observations of the modus operandi of children's museums that the programs result from the response of the children. What they like in the exhibits, what their questions lead to, what opinions they express on the games, the clubs and activities are the guide posts of the staff. True, the parents, teachers, and group leaders also make valuable suggestions, but the children's needs and interests tip the balance. Action, participation, and direct experience in the museum follow logically. From the simplest coloring sheet to the teenage lecture on aviation children are encouraged to act and think for themselves at the museum. Obviously there is plenty of opportunity for the growth of a child's knowledge of a given subject if he pursues through the classes, clubs, programs, and

his own reading the study of collections he likes best. For the majority of regular visitors, be they potential scholars or not, there is development of personality through sharing together with other children from near and far, these experiences of discovering and exploring the world in a new way; through achieving some goals of his own choice; and through directing himself to greater maturity both intellectually and socially.

Much has been written and said in the past fifty-six years to describe the rewards for children of experience in these museums. Some have chosen botany, zoology, or engineering as professions because a spark ignited for them there. Thousands of others look back upon their trips to the museums or to their membership in the clubs as the time when they discovered hobbies which have lasted throughout their lives. In Detroit we sum up our program by some words of action which we call touchstones:

SEE
TOUCH
WONDER
DO
THINK
LEARN
UNDERSTAND

Acknowledgement for slides loaned for this meeting is made to the following museums: Children's Nature Museum, Charlotte, North Carolina; Fort Worth Children's Museum, Fort Worth, Texas; The Children's Museum, Boston, Massachusetts; Piedmont Center Museum of Natural History, Worcester, Massachusetts; Nashville Children's Museum, Nashville, Tennessee; Brooklyn Children's Museum, Brooklyn, New York; Worcester Natural History Society, Worcester, Massachusetts; A. M. Chisholm Museum, Duluth, Minnesota; Wonder Workshop Junior Museum, Bridgeport, Connecticut; Indianapolis Children's Museum, Indianapolis, Indiana.

KOREA RECEIVES RECORD NUMBER OF GIFT COUPONS

A record total of $2,298 in the form of UNESCO Gift Coupons was received in July for educational reconstruction in Korea. The coupons will be used to buy classroom supplies for 82 schools. Technical equipment has been ordered for four engineering high schools, for the Chunchon Agricultural College and for the Mokpo Deaf School, which will receive equipment for a barber shop used in training handicapped children.

UNESCO Gift Coupons are a kind of international money order by which groups can make personalized gifts to needy schools, libraries, laboratories and other educational institutions in the less developed parts of the world. The coupons, which make shipping and foreign exchange problems as simple as mailing a letter, may be used to buy any article of an educational, scientific, or cultural nature.

CHEMISTRY TEACHING WITH MOVABLE MAGNETIC MODELS*

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One of the important problems in teaching general chemistry is the stimulation of the student's imagination so that he can formulate in his mind's eye a picture of molecules and ions reacting with one another. A great many excellent teaching aids are available for this purpose, but most of them have the disadvantage that the student sees the symbols and formulas of the reacting entities and products in fixed positions such as on a chart or on the blackboard. Occasionally he sees molecular models which, although they can be freely moved through space, usually cannot be used to demonstrate simply such transformations as the breaking of old bonds and the formation of new ones. The technique to be discussed here uses movable symbols and formulas which can be manipulated on a flat surface to illustrate various chemical and physical phenomena.

This method involves the use of symbols and formulas drawn on small pieces of cardboard (wood or metal) to which tiny magnets[1] have been attached. The cards can then be placed on a large panel made of steel or galvanized iron. Many of the newer blackboards have steel backing and are ideal for this purpose. Once in position the cards bearing the symbols and formulas can be manipulated easily by the instructor to illustrate the movement of atoms, molecules and ions as they react chemically and undergo physical changes.

For example, a very simple but impressive illustration of the fundamental difference between ionic and covalent compounds can be carried out by portraying the dissolution of an ionic compound and a covalent compound. Magnetized cards containing Na^+ and Cl^- are arranged in several rows on the panel to simulate the sodium chloride crystal structure of alternating sodium and chloride ions. Another portion of the panel is arrayed with cards each containing the formula for a water soluble covalent compound such as sugar or urea. The cards are placed in several neat rows to simulate the orderly arrangement of the molecules in the crystal. To picture the dissolution process, the instructor need only move several cards from each set away from the orderly arrangement. Of course the model of the ionic

* Presented at the Chemistry Section of the Central Association of Science and Mathematics Teachers, Friday, Nov. 25, 1955, Detroit, Mich.

[1] Magnets for this purpose can be purchased from several scientific apparatus companies. They can be attached to the cards with cellophane tape.

compound "dissolves" as individual ions whereas the covalent model "dissolves" retaining its molecular structure.

A second example helps to justify to students the need for writing ionic equations and at the same time aids in teaching them the principles behind the displacement reaction. The instructor performs the demonstration in which an iron nail is placed in a copper sulfate solution. Then an illustration of the probable path of the reaction using the movable models is carried out as follows:

The panel is set up with a large number of magnetized cards each containing the symbol Fe arranged in the shape of a nail. Sparsely arranged around the model of the nail are other cards some containing Cu^{++} and others marked with SO_4^{--} representing the dilute copper sulfate solution. The instructor moves a Cu^{++} card toward the Fe cards and upon collision between two such cards he overturns each of them. On the back of the Cu^{++} card is the symbol Cu and on the back of the Fe card is the symbol Fe^{++}. The Cu card replaces the Fe card in the outline of the nail and the Fe^{++} card is moved away from the nail model and into the 'solution'. This is repeated several times with the Cu^{++} cards and at least once with one of the SO_4^{--} cards to point out that such collisions do not result in reaction. Finally the equation for the reaction is written on the blackboard. Since the student cannot 'copy' the movable model illustrations into his notes the equations serve as reminders of the picture he has seen.

In a similar manner the atom scale picture of many other phenomena can be made more vivid to the beginning student in chemistry. Atomic structure, isotopes, atomic fission, chemical bonding, acid base relationships, electrolysis, chemical and physical equilibria have all been presented using this technique. There are many other possibilities.

NEW FILMS FOR MATHEMATICS CLASSES

A series of seven 16 mm. films dealing with the nature, unifying relationships, historical development, and uses of numbers as well as number systems and operations is now available for classroom use. The films are of a television series, UNDERSTANDING NUMBERS, presented by Phillip S. Jones of the University of Michigan. Each is 30 minutes in length. Films are available on a rental or sale basis from Indiana University, Audio-Visual Center. Further information about them will be provided by Indiana University upon request. The titles of films in the UNDERSTANDING NUMBERS series are: The Earliest Numbers, Base and Place, Big Numbers, Fundamental Operations, Short Cuts, Fractions, and New Numbers.

Play Tent is designed to look like the log cabin Davy Crockett lived in. It holds four or five young "Crocketts." The walls are tan canvas two and one-half feet high and the roof is waterproof canvas. The tent has 16 square feet of floor space and comes with poles, ropes and stakes.

JUDGE NOT LEST YE BE JUDGED*

A SCIENCE FAIR PROBLEM

ROBERT D. MACCURDY
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AND

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INTRODUCTION

The reader will probably consider the following statement to be "the understatement of the week"—JUDGING SCIENCE FAIRS IS A PROBLEM. The writers have had enough headaches over judging problems to consider trying anything that might work to improve the situation. They were aware that the problem was not a local one, for correspondence and conversations with science fair officials from other parts of the country revealed that judging was the major problem of all science fairs.

HISTORICAL REVIEW

Publications were not very helpful for they were quite scarce.[1] Nevertheless, they were examined. Robert D. MacCurdy and Thomas L. Bagshaw have published a paper entitled "Are Science Fair Judgments Fair?"[6] which pointed out the inconsistencies and the subjective errors of which experienced judges were guilty. The recommended solution to the problem was a new kind of score card which provided many all-or-none items; each having a very small weight in terms of the total score of the card. (See Fig. 1.) In practice, these cards proved to be valuable and speedy instruments for scoring projects—if the judge was familiar with this form from considerable use. Judges new to this card usually avoided it, for they felt it would take too much time. Since many judges in a fair may be new to the job, this card proved to be inadequate for all but limited purposes. A new solution to the problem needed to be discovered which would be fast, flexible, and suitable to the inexperienced judge.

HYPOTHESIS

Since the judge's problem is to pick winners whose projects are consistent with the set standards and which are acceptable, generally, to the majority of the public, the idea developed as follows: Use a large group of judges, who are a sample of the public, to judge the

* Paper presented at Florida Science Fair Work Conference, University of Florida, August 25–26, 1955.

projects, using any methods they choose, but being sure that they are aware of the set standards of the state science fair committee. This means selection by rank order only.

Observations

In order to test this method, we decided to use it in our own local science fair. The fair was conducted as usual and as described by the students of Dr. John G. Read[11] and MacCurdy and Leacy.[7] In this instance, however, the method of parallel judging was performed as described in the study of MacCurdy and Bagshaw.[6] Twenty-five of the most experienced judges in the area were available and they scored the projects using the standard science fair score card and its general standards of judgment. (See Figs. 2a and 2b.) Each project was scored three times and the average of the three was considered to be the final official score for that project. The projects were then placed in order according to score, as is shown on Table I, columns 2 and 3.

A special group of people was invited to serve as "rank order judges." These people were mainly elementary and junior high school teachers in the town. Some of the school administration and guidance counselors were also invited. These judges were given a rank order score card (see Fig. 3) and were asked to be "roughly guided if they like" by the standards printed on the back of the score card. (These were state standards, the same as on the official score card. See Fig. 2b.) They were asked to consider especially the student's work in terms of a school activity and then to select, from all the projects in the fair, the best ten projects, each judge using his own judging standards. They then listed the ten top projects, in order of rank, on their score cards. These rank order score cards were evaluated by assigning points to the positions thus: First place—10 points; Second place—9 points; Third place—8 points, etc. All points awarded to each project were then added up, the total being the score for that project. This is shown on Table I, columns 4 and 5.

Discussion

Many advantages were observed while using the rank order score cards. As the rank order judges were all from the local school system, they were readily available. In addition, they enjoyed the opportunity to visit the high school to see their colleagues and to talk with their former students who were science fair contestants. Much good will and integration was thereby achieved. Many of the judges asked the high school science fair contestants to bring their projects back down to their junior high and elementary schools to show to the

youngsters. This, of course, was wonderful publicity for the high school science courses.

Case #A12 was interesting. It was an extreme deviate from the pattern. While this project scored very high by official judging with a well developed project, he scored much lower by rank order scoring. This probably was due to the fact that the project was not an experimental or research type of project, but a collection type of project. Other similar inconsistencies could also be explained in this way. However, if all projects were either of the research type or of the collection or applied science type these inconsistencies might disappear.

Conclusions

The following conclusions can thus be drawn:

1. It was an easier task to obtain local teachers for rank order judging than to obtain experienced judges for official judging. This fact suggests a solution to the judge shortage problem on the local level.

Table I

Order of Placement by Official and Rank Score Cards

Project #	Official Score	Position	Rank Order Score	Position
(1)	(2)	(3)	(4)	(5)
C7	03	1	200	1
A3	83	2	110	3
A12	76	3	63	10
C9	72	4	134	2
A14	67	5	89	6
A1	65	6	22	17
B1	63	7	77	9
C5	62	8	90	5
C2	55	9	31	15
A9	52	10	19	18
B9	52	11	102	4
C12	52	12	88	7
B5	49	13	86	8
C4	49	14	5	23
A13	49	15	62	11
B11	47	16	43	13
C11	42	17	28	16
A10	36	18	9	21
C1	35	19	3	24
B8	33	20	14	20
A8	32	21	19	19
C3	30	22	51	12
C13	28	23	39	14

FIG. 1

SCIENCE FAIR SCORE CARD

Project Title——————————— Project # ________

Items for Scoring. Each is an All or None Item.

A	SCIENTIFIC METHODS USED IN SOLVING THE PROBLEM	30	
	1. Evidence that the problem evolved naturally from life	2	—
	2. Evidence that the search for related facts was made	3	—
	3. Evidence that a hypothesis was developed	4	—
	4. Evidence that controlled observations were made	5	—
	5. Evidence that findings were tested for accuracy	6	—
	6. Evidence that conclusions were limited to data	5	—
	7. Evidence that credit was recognized in bibliography	3	—
	8. Evidence that plans exist to share the truth	2	—
B	ADVANCEMENT IN SCIENCE FOR THE CONTESTANT	20	
	1. Evidence that there is a new interest in science	4	—
	2. Evidence that there is a new scientific knowledge	4	—
	3. Evidence that there is an understanding of the scientific method	3	—
	4. Evidence that there is a new respect for scientists	3	—
	5. Evidence that there is a scientific attitude	3	—
	6. Evidence that study is of a school duration	3	—
C	INGENUITY OF CONSTRUCTION, TECHNICAL SKILL, WORKMANSHIP	20	
	1. Evidence of all possible use of everyday materials	4	—
	2. Evidence of precision, order, care, skill in building	5	—
	3. Evidence of durability, portability & safety features	5	—
	4. Evidence of no professional assistance	4	—
	5. Evidence of creative imagination in design	2	—
D	THOROUGHNESS	10	
	1. Evidence that project carries out its purpose	2	—
	2. Evidence that observations were accurately made	2	—
	3. Evidence that essentials of scientific method were used	1	—
	4. Evidence that labelling is clear	1	—
	5. Evidence that it works	3	—
	6. Evidence of graphic or pictorial illustrations	1	—
E	ORIGINALITY OF CONCEPT	10	
	1. Evidence of an original idea	2	—
	2. Evidence of new methods used	2	—
	3. Evidence of any apparatus developed	2	—
	4. Evidence of any materials used	2	—
	5. Evidence of any conclusions reached	2	—
F	SOCIAL IMPLICATIONS	5	
	1. Evidence that contestant sees its use today	3	—
	2. Evidence that contestant sees its use tomorrow	2	—

G	DRAMATIC VALUE	5	
	1. Evidence that it attracts people to look closer 2. Evidence that it is self-evident in explanation	2 3	— —
H	TOTAL SCORE	100	
	Judge's Name: · Address:		
	Time judging started: Time stoped: Total		

FIG. 2-A

SCIENCE FAIR SCORE CARD

1955

Project Title ________________ Project # ________

1. Scientific Approach to the Problem	40	—
2. Advancement in Science of Contestant	20	—
3. Ingenuity of Construction and Technical Skill and Workmanship	20	—
4. Thoroughness	20	—
Total Score	100	—

Judge's Name ________________
Time judging started on this project: ________ Time Stopped: ________
Total Time: ________

FIG. 2-B

1955 MASSACHUSETTS SCIENCE FAIR
JUDGING STANDARDS

1. *Scientific Approach to the Problem* *40 Points*

The exhibit should show clearly the results of application of the scientific methods to the problem chosen by the exhibitor. The selection of the problem itself ought to tend to originality and avoid being servile copies of known experiments. Particular stress should be laid on the background of the problem, its orderly analysis, its experimental approach, the collection and adequate recording of observations and their analysis. Of importance also should be the clear presentation of the experiment as a coherent whole.

2. *Advancement in Science of the Contestant* *20 Points*

One of the aims of the fair is to discover young potential scientists with full awareness of the social implications of science and science's impact on society. The exhibit should indicate clearly the contribution made to the young scientist's own development mentally as well as to the development of his interest in research and to the products of research in science.

3. *Ingenuity of Construction and Technical Skill and Workmanship* *20 Points*

Neatness of construction and safe presentation as well as ingenuity in the use and adaptation of everyday common materials is important.

4. *Thoroughness* *20 Points*

The exhibit should carry out its purpose to completion within the scope of the problem, in a forthright manner, requiring a minimum of detailed explanations. A vivid presentation of the problem and its results may be better than many pages of text or mere displays of animals or collections of material.

FIG. 3

RANKING SCORE CARD

Project Title Project #

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________
5. ______________________________
6. ______________________________
7. ______________________________
8. ______________________________
9. ______________________________
10. ______________________________

2. The much simpler rank order system of judgment selected approximately the same group of winners (although not in the same order) as the more involved official judgment system.

3. The use of local teachers as rank order judges was a successful experience, for it featured:

   a. Promotion of good inter-school relations
   b. Integration between the high school and the lower schools
   c. Publicity for high school science
   d. Ease of obtaining judges
   e. Accurate selection of winners
   f. Simplicity of fair operations

4. The elimination of experienced official judges on the local fair level is recommended. These busy people can be reserved for regional or state level fairs.

5. The eventual graduation of local rank order judges to the level of experienced official judges is anticipated as the valuable experience gained in their rank order judging makes them better as judges for official score cards.

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A TEACHER SPEAKS OUT

There's an abundance of statistics and comments these days on the problem of educating students in the physical sciences. But we don't believe any of them tell the story better than an unsolicited letter just received by the Manufacturing Chemists' Association from a college chemistry teacher. Writing on the eve of the White House Conference on Education, he puts down his heartfelt experience both as teacher and parent.

"We are all concerned," he says, "with the decreased enrollment in our schools in chemistry, physics and mathematics *on all levels*. The result is tragic—an insufficient number of teachers, research personnel, engineers and technicians —*on all levels*. Why is it happening? I think I know some of the reasons.

"Students as a group do not want to study the difficult subjects. Too many enroll in watered-down courses and memorization courses. In these courses an 'A' or 'B' is almost guaranteed. Students have told me that they are crazy to take chemistry—too much study, too much laboratory and too much mathematics and they are not sure of an 'A' or 'B.'

"This institution has 1900 students—about 550 freshmen. The physics professor has 14 students, four of whom are freshmen. These are facts. Several years ago we had sections of 36–40 in both inorganic chemistry and physics. When applicants for the freshman class are interviewed and chemistry, physics or mathematics are mentioned they shy away—as from a plague. They say in no uncertain terms that they want none of that! What has caused all this in the last few years?

"The textbooks of inorganic chemistry are watered-down apologies or are so formidable that they are frightening. There seem to be too few good, sound texts for the average student who is interested and wants to do a good job. I have texts on my desk of 875, 570, 730 and 650 pages. Much of the material in many of these can only be assimilated by the brightest student. (One of my younger colleagues has just told me that his freshman chemistry text had just over 1000 pages. His students couldn't use it and were scared of it.) Such texts are enough to discourage and frighten the average student fresh from secondary school. These youngsters are nervous, immature, apprehensive and unsure of themselves. They must be brought along slowly and patiently and not have this high powered material hurled at them in concentrated chunks.

—*Chemical News*

Remote Control Crane for junior construction men operates from a box held in one hand. A touch of one button causes the bucket to load, raise, unload and lower. A second button makes the toy crane go forward or backward. Powered by two flashlight batteries, the crane and truck are made of plastic.

THE DEVELOPMENT OF A CONSERVATION PROGRAM IN THE PUBLIC SCHOOLS*

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It is truly a real pleasure for me to meet with you today in the interests of conservation education. I need to go to no great lengths in stressing the importance of the need that exists today for the active participation of all of us in this area. Much has been written, a lot has been said, and we see everywhere around us the concern that exists on the part of people to secure adequate water supply, to see that our wildlife is well managed, and that wise practices of soil use are in force. Furthermore, we need to give more attention to the development of a sound program of conservation education in our schools. I know you are interested, and I am happy to have the opportunity of discussing it with you.

It would seem to me that time and experience have shown that we are in need of a more realistic approach to the teaching of conservation. Requirement of a minimum amount of time to be devoted to the teaching of principles of conservation by statutory demand has not been the answer, nor has the stipulation that certain designated courses should include a unit of work pointed toward the study of our natural resources proved to be successful. I am not so sure, either, that conservation can or should be taught from a book apart by itself when, in every community regardless of size or location, there is an abundance of opportunity available through which to teach the appreciations, understandings, attitudes and the skills of conservation. Here, too, is the media for real student interest and practical application of the things learned in the classroom. Here too, is opportunity for practical application in the classroom of understandings gained in the forest. Further, if we are really interested in bringing our schools into closer working relationship with our respective communities, there is no finer way of approach than by calling upon the specialists available in the community for help both in the planning and in the teaching of this important area. The Soil Conservation Service, Department of Agriculture, and the Conservation Department are all willing to serve and are available as a resource to the schools.

Thus, in developing a program of resource education in our public schools, the study of our natural resources can be closely integrated

* Presented at the Conservation section of the Central Association of Science and Mathematics Teachers, Friday, Nov. 25, 1955, Detroit, Mich.

through careful planning with all subjects and classroom work. It is to be pointed out that the foregoing statement does not mean that a unit is to be included in all subjects taught but, rather, the skills or facts taught in the individual classes can be supported and vitalized through using our natural resources as a vehicle of instruction. Conservation education can implement all of our teaching. To illustrate specifically, a sixth grade class in arithmetic concerned with the fractions or measurement could lay out an area or a fifth acre plot, determine the fractional part of each species of tree it contains or the number of pulpwood sticks needed for a cord. In the social studies field, a class of twelfth grade students in American Problems might be concerned with the overall study of production and the factors involved of land, labor, and capital. Here would be an opportunity for students to determine in a very real way how the land is a factor in their own economy. Interest will be high and study meaningful to the students and at the same time they are learning values in conservation. If careful planning has been done, conservation education will not be incidental but a fundamental part of the study.

I believe, however, that the first step that needs to be recognized in developing such a program at the local level is that of developing staff awareness of the importance of such a program in addition to making certain that all staff members have a complete understanding of plans developed. Without the support of the staff and their wholehearted cooperation, any program, regardless of its nature, becomes a meaningless structure outlined on paper. We found that in our little city of approximately 9,000 we have 15 wood-using industries that employ 927 men. In the course of their operation in one year, 55½ million board feet of lumber was used, and they did an annual business of $13,463,000. The strange and the sad part of the whole story lay in the fact that 95% of the wood used came from the West Coast to be used in a county where over 50% of the land is non-agricultural and that once was a part of the biggest pine producing regions in the country. This illustrates the conditions which exist in just one of our natural resources, our forests. When teachers are so appraised, they are alerted and ready to assist in a program that will rectify such conditions. The important thing gained is not so much the facts made known but rather the meaningful way it creates interest and support in developing a program to provide a more adequate approach to the teaching of conservation. Teachers need to know the facts; teachers need to have mutual understanding, and they need to be taken along with the preliminary and the basic planning. With such staff support assured, the stage is set for further steps to be taken together in this task.

We found that the type of program described in the previous pages

can be successfully launched at an early age. For kindergarten children, a field trip to the forest can be fruitful. There must be, of course, adequate supervision, and the trip must be planned to point out things that will be interesting to and understood by that age group. They will ask such questions as: Why was this tree cut down? Do porcupines hurt the trees when they gnaw on them? The alert teacher will follow up on such interest indication by perhaps making a story of their trip with the group or letting them draw what they have seen. I don't believe we expect children in kindergarten to understand all the reasons for what they have seen, but it is surprising to see their interest in our natural resources and also how long this interest continues after the trip is over.

The social studies program in the primary grades that revolves around the study of the inter-dependence of the home, neighborhood and community can be supported in a very real way through the study of our natural resources. Nature has communities in which plants, and animals assist one another in supplying food, and shelter. Here is a good parallel to be drawn. In the upper grades as the interest in the social studies broadens, it is even more desirable and advantageous to capitalize on conservation to implement our teaching. How can we better teach an understanding of the early colonial life in America than by helping children to understand the out-of-doors and the manner in which the early American had to rely upon nature for nearly total support? Mention has already been made of the application that can be made in the area of arithmetic. Children want to learn and tell about things with which they are acquainted, and hence language arts can be included. Science, of course, is a natural. Health and physical education can easily be drawn into the picture.

In our English program on the junior and senior high school levels conservation and field trips give purpose to communication both oral and written. People wish to tell others about something they have experienced. How often do we find teachers in the classroom asking for descriptive paragraphs to be written by students about topics taken from pages of a workbook that might be completely foreign to the experience of those writing? Here is a natural approach to the teaching of functional grammar and for using the steps in attacking a problem. In other classes in our high schools, the same principle applies. Students in agricultural classes should see in action sound soil practices on the farms. Conservation can implement our entire program and at the same time give purpose and meaning to *our classroom* work.

DEVELOPING DEMONSTRATIONS IN PHYSICS WITH SIMPLE EQUIPMENT*

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In 1951[1] the last year for which figures are readily available the colleges of the United States graduated about twenty thousand persons with technical education in the field of physical science.[2] This figure includes engineers of all sorts as well as physicists, chemists and mathematicians. This twenty thousand was the total number available to both government and industry for maintaining and increasing the technology of the country. The number did not commence to meet the demand. It is conservatively estimated that had they been available in 1951[3] government and industry would have employed fifty thousand technically trained individuals. Moreover, this need for technical education is found to increase with the increase in automation. Many important industries envision the time when even the man at the machine will find it necessary to have considerable understanding of theoretical processes. Inspection as a word for the examination for imperfections, of the products of our factory assembly lines is obsolete. The term is now "quality control." It is a matter of sampling and deviation from a norm among the samples. It needs mathematicians with competencies in engineering, physics and chemistry.

Where is industry and government to get this increased number of technically trained people? The sole source is from the high school. Those now enrolled and to be enrolled in high school courses in physics, chemistry and mathematics must furnish this increase. Yet the percentage of high school students studying high school physics has been constantly decreasing for the past fifty years so that in spite of the greatly increased number of students in the high school there has been little increase in the number of those electing to study physics.

The enrollment in our high schools has increased from 203,000 in 1890[4] to over 5,500,000 in 1950 an increase of about 2700 %. Yet in

* Presented at the Physics Section of the Central Association of Science and Mathematics Teachers, Friday, Nov. 25, 1905, Detroit, Mich.

[1] Offerings and Enrollments in High School Subjects, Chap. 5, Biennial Survey of Ed., Federal Sec. Agency, Washington, 1951.

[2] P. G. Johnson, "On School and Science Enrollment in the Fall of 1952," Office of Education, Mimeographed, 1952.

[3] G. R. Harrison, "Role of the Secondary School in the Teaching of Science," *Physics Today*, Vol. 5, No. 6, June 1952.

[4] W. C. Kelly, "Physics in the Public High School," *Physics Today*, Volume 8, Number 3, March 1955.

that same period there has been less than 300% increase in the number studying high school physics. Possibly of greater significance is the fact that there has been an actual decrease in the numbers electing high school physics since 1950. Next year the high schools of this country will graduate over a million seniors but not more than 150,000[5] of them will have studied physics. If forty percent of these, a very high estimate indeed, were to become engineers, teachers of science, and physicists they would not supply the demand of 1960.

How could this sad situation have developed? Is it because physics is too difficult for most high school students? One doubts this. It is true some authorities maintain that an intelligence quotient of 115 is needed to master all of the concepts of physics and engineering but a high school course does not presume such absolute mastery. In any case, the high school fails to hold annually many times this needed number of students with intelligence quotients of 115 or greater.

The answer is not to be found in making physics "easier." So-called "watering down" processes defeat the very purpose for which they are intended. Teaching less and less about more and more can not be expected to produce the scientists and engineers who will build nuclear engines, send rockets to the moon, take potable water from the sea, and do the thousand and one other tasks demanded of technicians in this age of science. However, these statements are not to be construed to mean that there shall not be differential treatment of pupils in physics according to their abilities and interests. Possibly there is more need for the technician who can manage the machine than there is for the one who can plan it. Both can be educated in the same physics class by those who have the will and the time. The need is not for less or easier subject matter, the real need is for more competent education.

Since its inception as a field of study physics has been an experimental science. Presented as a set of theoretical principles with little proof, or assigned from the pages of a text book physics loses much of its appeal. Physical principles must be demonstrated for one to appreciate them. Inasmuch as the high school student usually is much more interested in doing things than in reading about them it would seem that physics should have been particularly appealing. That it has not is due in large part to failure to present it by demonstration. It is only by experiment that the physics teacher can develop scientific attitudes and scientific methods in the high school physics student. These attitudes and methods are primary objectives of all science teaching. They are the things that can make physics different and appealing to the high school student.

[5] P. F. Brandwein, "Obstacles to Increased Physics Enrollment," *American Journal of Physics*, 23, 537 (1955).

It may be argued that demonstrations are time consuming. They probably are but it would seem to be better to teach a few things understandably to a greater number of people than to teach many things poorly to a few. Anyway a little thought devoted to such things as combining the teaching of uniform and accelerated motion with Newton's Laws of Motion, presenting composition and resolution of forces as a single topic, and eliminating material with little or no present day importance could provide all of the time needed.

Nor is it necessary to have expensive apparatus with which to demonstrate. Most of the principles of high school physics can be demonstrated with apparatus found in the community. Much of the needed apparatus can be built in the average school shop, and for very small cost. Such apparatus is more desirable to both teacher and student not only because its usual simplicity makes understanding of principles easier but also because of its local origin.

This need for careful, simple demonstrations is so important to the rejuvenation of physics as a major field of study in the high school that a few principles will now be demonstrated in shortened form. All of the experiments chosen are from the field of forces and motion. This is not the only field where this type of demonstration is possible. Several others are on the tables at my right. Most of them are operative.

1. Parallel Forces and Moments of Forces in Static Equilibrium.[6]

This apparatus consists of a rigid bar about six feet long mounted at either end on simple knife edges over household spring scales as shown in Figure 1. The bar is marked off in feet. The scales have been adjusted to read zero with the bar in place, thus simulating a weightless bar. A twelve pound weight placed at the mid point furnishes a

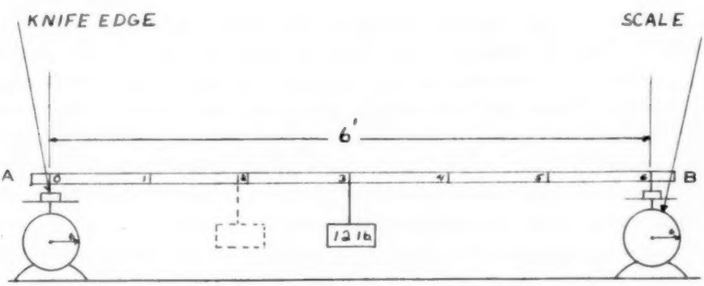


FIG. 1.

[6] Apparatus developed by H. L. Smith, Michigan State Normal College.

downward force. The scales at either end furnish the upward forces to bring the apparatus into static equilibrium. As will be observed each scale reads six pounds with the weight in this position, and the sum of the upward acting forces is equal to the downward acting force. Moving the weight to some other position on the bar changes only the reading on the scales. The sum of the upward acting forces remains equal to the downward acting force. Using several downward acting forces does not change this result. Thus one is forced to conclude that when forces are statically balanced on a bar the sum of the upward acting forces must be equal to the sum of the downward acting forces, i.e. $\sum Fy=0$. This is condition I, i.e. no translation, for static equilibrium of forces. Obviously, this apparatus also meets condition II, i.e. there can be no rotation, when parallel forces are in static equilibrium on a bar. Let us see how this happens. Consider A a pivot point and calculate the moments of forces B and C about A where the moment of a force is taken to mean its effectiveness in producing rotation and is defined as force times the perpendicular distance of the force from the pivot. Force B is six pounds with a distance of six feet from A. Its moment is $6\times 6=36$ lbs. ft. in a counter clockwise direction. Force C is twelve pounds at three feet from A. Its moment is $3\times 12=36$ lbs. ft. in a clockwise direction. The counter clockwise moment is equal to the clockwise moment. This condition of equality of counter clockwise and clockwise moments will remain true without regard to the pivot point chosen or the values of forces A, B and C so long as the bar is at rest. It is now apparent that when forces are in static equilibrium not only must the up forces be equal to the down forces but also the clockwise moments must be equal to the counter clockwise moments, and one may proceed by problem and illustration to use the idea.

2. Newton's Second Law

Newton's second law is probably the most important principle stated in classical physics. The ideas in work and energy are based on it. It is fundamental to the concepts of linear and rotational acceleration. Most high school physics texts will state, "change in motion is proportional to the force applied and takes place in the direction of the force," and proceed to write $F=ma$ or some variation of it. Rarely is any experimental evidence offered to support either the statement of the law or the equation written from it.

This piece of apparatus (Figure 2) is designed to demonstrate the law qualitatively. It consists of a light metal cylinder mounted on bearings of small friction in a U-shaped holder which may be clamped in a horizontal position some feet above the floor. A circular paper belt nearly long enough to reach the floor is placed over the cylinder

and equal large masses, M_1, and M_2 are mounted midway of the paper belt on each side. Four small equal masses (about 5 gms each) are mounted on the paper with two near M_1 and two near M_2. Call each of these m. Inasmuch as the masses on each side of the belt are equal the gravitational forces on each side are equal and no motion will result. Now transfer one small mass from M_1 to M_2. In this case while the total mass on the belt remains the same the mass at M_2 is $2m$ greater than at M_1 and there is consequently an unbalanced force of 2 mg. downward at M_2. The system will move toward M_2. Watch it. At the instant of start it is at rest. With the passage of each instant of time it travels with greater and greater velocity downward. One may truly write: $\Delta v \alpha \Delta t$ where v and t stand for velocity and time respectively and Δ is written to denote "change in."

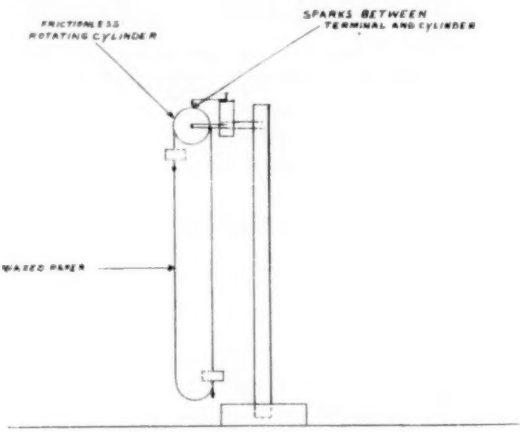


FIG. 2.

Now transfer the other small mass from M_1 to M_2. The mass at M_2 is now $4m$ greater and there is an unbalanced force of 4 mg. downward at M_2. The system will again move toward M_2. Watch it. Observation at any same instant of time will show it to be moving with markedly greater velocity than when the force was 2 mg. Timing with an interval timer or stop watch will show a descent of the same distance in half the previous time, i.e. the velocity is twice as great. One may write $\Delta v \alpha f$ where f is written for force. Now mount additional heavy masses at M_1 and M_2 and repeat the maneuvers of the last two paragraphs. The velocity of M_2 downward will be very much less in each case, and one may write $\Delta v \alpha (1/M)$ where $1/M$ is written to indicate an inverse proportion.

From all of this we have $\Delta v \alpha \Delta t$; $\Delta v \alpha f$; and $\Delta v \alpha (1/M)$ and from

them we may write $\Delta v \alpha f \cdot \Delta t \cdot (1/M)$ by noting that if a thing is proportional to each of several things it is proportional to their product. If one may treat this proportionally like a mathematical equation and clear it of fractions one has:

$$M\Delta v \alpha f \Delta t \tag{1}$$

The left hand member above is called quantity of motion or more properly change in momentum and is used to define the term. The right hand member is called impulse. Hence it would be better to say for Newton's second law "change in momentum is proportional to the impulse applied and takes place in that direction. Equation (1) above may be rewritten $f \alpha M\Delta v/\Delta t$ where $\Delta v/\Delta t = a$ by definition so one finally gets

$$f \alpha ma \tag{2}$$

Both (1) and (2) above may now be used with some understanding to explain what happens in a rifle or pistol barrel when the trigger is pulled or to determine the behavior of an arrow when it is released from the bow string. If proper units are chosen both (1) and (2) may be written as an equality and exact values determined.

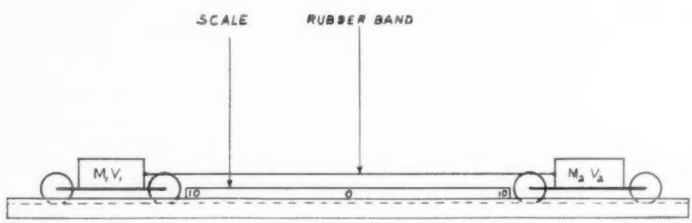


FIG. 3

3. Action and Reaction—Newton's Third Law

Newton's third law is usually stated in a high school physics text by saying "Action is equal to reaction." Often little attempt is made to define either term, and illustrations used tend to make the students believe that the forces and velocities involved are always internal. Simple apparatus consisting of two Hall's carriages of only approximately equal masses running in grooves in a board and connected by rubber bands as shown in Figure 3 may be used to clear all misconceptions. Move the cars a fixed distance apart putting a tension, F, in the rubber bands and on each car. Upon release of the cars this tension, F, will not be constant in time but at any given instant of time will be the same on each car. Therefore, one may write for the

car at the left: $M_L \cdot V_L = \overline{F} \cdot t$ (1) and for the car at the right $M_R \cdot V_R = \overline{F}t$ (2) where $\overline{F}$ is some average tension and t is the time after release until the cars meet. It follows that $M_L \cdot V_L = M_R V_R$ should hold true. These velocities are not easily measurable but, since time of travel is equal for each, distance of travel by each car should be proportional to its velocity. When $M_R = M_L$, V_R should equal V_L and the cars should meet midway. If $2M_R = M_L$, V_R will be equal to $2V_L$ and the cars should meet two thirds of the distance from the lesser mass. Thus it is shown that where impulses are equal momentums are also equal, i.e. $M_1V_1 = M_2V_2$ or generally that action is equal to reaction where action and reaction are defined as momentum. If it is desired the apparatus may also be adapted to show that the algebraic sum of the momentums before impact is equal to the algebraic sum of the momentums after impact but in this case care must be taken to have all masses moving in the same straight line.

Of course the demonstrations used here cover just a small part of physics. They can not be expected to serve the work of a whole year. They show only what can be done in a single field with inexpensive apparatus and a modicum of ingenuity. Every other area of physics is just as susceptable to demonstration with similar apparatus.

A half sheet of paper may be used to demonstrate Bernoulli's Principle and explain why an airplane flies. A spool empty of thread and a small card may be used for the same purpose. Table forks are not tuning forks but they can be made to serve. Pascal's Law can be shown with a medicine dropper, a flat whiskey bottle, and some water,—equipment available in most communities. The relation between pressure and depth in a liquid can be demonstrated using a tall fruit juice can with equal sized holes punched in its sides at different distances from the bottom. A very small spark of genius plus a little thought will serve to produce enough simple, inexpensive apparatus for all of physics.

Somewhere, somehow, this writer has become convinced that the schools of the United States are as responsible for the internal security and well-being of our democracy as are the Army, the Navy and Air Force responsible for its external defense. If this be true it behooves every teacher of science or mathematics to do his most competent, appealing, and alluring job of teaching else we could win a cold war on the diplomatic and military fronts in Europe, Africa and Asia but lose it ultimately in the factories and research laboratories at home.

Coloring Toy lets children create their own world of color, drawing, shapes and play. Containing 16 crayons, clips, and eight colored cards with 49 different shapes to punch out, the young imaginator can make jumping jacks or fairy tale scenes.

EXAMINATION SCORES AND THE SIGN TEST

R. F. GRAESSER
University of Arizona, Tucson, Arizona

A class has studied two parts of a course and an examination has been given over each part. The examination scores are higher for one part than for the other. Can we be sure that the part with the higher scores has been more thoroughly mastered? Examinations are but samples of students' knowledge. Could another pair of examinations (samples) yield different, even contrary results? Clearly, this is a question about "the fluctuations of sampling." Other pairs of examinations could yield still other results. We wish to know whether our actual difference in scores could be due to these fluctuations of sampling or whether it is very unlikely that it could be due to this cause. In the latter case it would indicate a real difference in the mastery of the two parts of the course. There is a simple method of answering this question. It is called the sign test, and it has an easy mathematical derivation. To obtain this derivation, suppose that there has been equal mastery of the subject matter of both examinations. The probability that a student will earn a higher score on the first examination is then one half. The probability that he will earn a higher score on the second examination is also one half. The possibility of a tie is here excluded since its probability would be nil if we could measure students' knowledge exactly. Suppose we call a higher score on the first examination a success. The probability that any student will succeed is then one half. In a class of n students the probability that i students succeed and $n-i$ students do not is $nCi(\frac{1}{2})^n$, where nCi means the number of combinations of n things taken i at a time. (See any college algebra for this and subsequent probabilities.) The probability of r or fewer successes is

$$\sum_{i=0}^{r} nCi(\tfrac{1}{2})^n,$$

and the probability of $n-r$ or more successes is

$$\sum_{i=n-r}^{n} nCi(\tfrac{1}{2})^n.$$

The probability that either one or the other of these events happen is

$$P=\sum_{i=0}^{r} nCi(\tfrac{1}{2})^n+\sum_{i=n-r}^{n} nCi(\tfrac{1}{2})^n.$$

Clearly it is possible to choose an r_0 so that $P\leqq 0.05$ if $r\leqq r_0$, and

$P > 0.05$ if $r > r_0$. Then r_0 is called the five per cent critical value of r. It may be calculated and tabulated for various values of n as in the table.

To apply the sign test to determine whether there has been an unequal mastery of the subject matter in two examinations, we may proceed as follows. To each student who succeeds, i.e., has a higher score on the first examination, we give a plus sign; to all others we give a minus sign after ties have been excluded. From this procedure, we have the name sign test. Of course, either examination may be considered the first examination, and changing this designation would change all pluses to minuses and vice versa. Hence we let r equal the number of pluses or of minuses, whichever is the smaller. The total number of pluses and minuses is then n. Suppose that, for the number n, the value of r is less than or equal to the r_0 given by the table. Then either a rare event with probability less than 0.05 has happened, or the hypothesis of equal mastery of subject matter is false. Since the probability of the rare event is small, we choose the latter alternative.

FIVE PER CENT CRITICAL VALUES OF r

n	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
r_0	0	0	0	0	0	0	0	0	1	1	1	2	2	2	3
n	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
r_0	3	4	4	4	5	5	5	6	6	7	7	7	8	8	9
n	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
r_0	9	9	10	10	11	11	12	12	12	13	13	14	14	15	15
n	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
r_0	15	16	16	17	17	18	18	18	19	19	20	20	21	21	21
n	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75
r_0	22	22	23	23	24	24	25	25	25	26	26	27	27	28	28
n	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90
r_0	28	29	29	30	30	31	31	32	32	32	33	33	34	34	35

For example, there are 10 pluses and 25 minuses in a class. Then $n=35$, $r=10$. Referring to the table with $n=35$, we see that the corresponding critical value r_0 is 11. Since $10<11$, we conclude that our test indicates an unequal mastery of the subject matter of the two examinations. If we had had $n=35$ but $r=15$, we would have concluded that as far as our test shows, there has been an equal mastery of subject matter.

The question might be asked why not merely compare the mean scores on the two examinations? Of course, the difference in the mean scores would then need to be tested to see whether it might be the result of fluctuations of sampling. The usual methods for doing this involve the assumption that the distributions of the scores on the two examinations are normal, i.e., they follow the normal curve. The sign test is more quickly applied than testing the mean scores, and it does not involve this assumption of normality.

Instead of wishing to test for a possible difference in mastery of subject matter, we might wish to test for a possible difference in the difficulty of two examinations covering the same subject matter. The two examinations could then be given to the same class and the scores tested as above.

SCIENCE FELLOWSHIPS AT CASE

For the tenth consecutive year Case Institute of Technology will offer fifty all-expense General Electric Science Fellowships to preparatory and high school teachers of physics from the north central states area for a special six-week study program that will run from June 17 through July 27, 1956.

In announcing this year's program, Dr. Elmer Hutchisson, dean of the graduate school and director of research at Case, said that applicants for the fellowships, sponsored by the General Electric Company, must be college graduates, possess experience in preparatory or high school teaching, and be certified to teach in their respective states.

The program is open to qualified teachers from: Illinois, Indiana, Iowa, Kentucky, Michigan, Missouri, Minnesota, Ohio, Western Pennsylvania, Tennessee, West Virginia, and Wisconsin. Travelling expenses to and from Cleveland, Ohio, as well as the cost of living on the Case campus, books, tuition, and fees are included in each fellowship grant.

Purpose of the program is two-fold: To provide preparatory and high school science teachers with a comprehensive review of the physical sciences and to present an introduction to the most recent developments in nuclear physics.

Applications for the 1956 GE Science Fellowships may be obtained from:

Dean Elmer Hutchisson
Case Institute of Technology
10900 Euclid Avenue
Cleveland 6, Ohio

In addition to the study program at Case, The General Electric Company will also offer summer courses for high school math teachers at Rensselaer Polytechnic Institute, Troy, N. Y.; a summer program for high school math teachers at Purdue University, Lafayette, Indiana; and summer courses for secondary school chemistry and physics teachers from northeastern states at Union College, Schenectady, N. Y.

EXPERIENCES WITH AIR PRESSURE*

ANTHONY E. CORDELL
Grayling School, 744 W. Adeline, Detroit 3, Mich.

With the first breath of air that a baby draws, he begins his experiences with air and air pressure. From then on, the child is living in an ocean of air. Although he has many experiences with air in his everyday living, he is often not aware of the air that surrounds him.

In our science teachings, we want to bring out many interesting experiences that will help children to understand the simple, but important science concepts about air that are involved in his everyday living. In that way, we can help children to understand many things that happen in their everyday environment, and establish cause and effect relationships relating to air and air pressure.

First we need to establish the concept that air is all around us. Even though we cannot see it, we can feel it when it moves, and we can see it move things around us. Children have many common experiences that show that air is all around us. When they run, they can feel the air press against them. Moving air helps them to fly their kites, sail their boats, or fly their toy airplanes. They have many toys that need air to make them work. To help them see that air is all around us, have a child hold an open sheet of newspaper in front of himself; then try to move the newspaper quickly in and out or up and down. He can feel the air press against the paper. Blow some milkweed seeds into the air. They can see that the seed parachutes float through the air. Call their attention to the fact that when they blow the seeds, they need air to do it. Repeat this, using wind made by moving a piece of stiff cardboard near the seed parachute.

There are many experiences that we can give children to help them to understand that objects which appear empty are really filled with air. Float a cork on the surface of some water in a large container like a battery jar. Ask children to push the cork to the bottom of the container without touching the cork. When they cannot do it, show them an apparently empty glass or jar. Direct their observation to the fact that they cannot see or feel anything inside the glass. With the inverted glass, push the cork down into the water. They will notice that water does not enter the glass. Repeat this experiment, but this time tip the glass when it is underwater. They will see bubbles of air rise out of the glass, and water will enter the inverted glass.

The hiccup bottle is another interesting experiment children like to

* Presented at the Elementary Science Section of the Central Association of Science and Mathematics Teachers, Friday Nov. 25, 1955, Detroit, Mich.

do. Put a long stemmed funnel or thistle tube in a one holed stopper fitted to a pint bottle. When water is poured into the funnel, an interesting effect is produced when air spurts out of the funnel as water goes down into the bottle.

That air exerts pressure is a more difficult concept for children to understand. It is difficult for them to accept the fact that air has weight, even though many common things in their everyday experiences work by means of air pressure. Children have various toys with rubber suction cups. They are familiar with common household articles such as suction cup coat hangers, fountain pens, eye droppers, plumbers force cups, drinking straws, etc. Children say these things work by "suction." There are many simple experiments we can do to show that air has pressure. Let children squeeze the rubber bulb from an eye dropper. When they hold the open end against their skin and let go, the bulb sticks to the smooth skin. Have someone try to drink water or milk through a glass drinking straw. They can do it easily. Now put the glass straw through a one hole rubber cork set firmly in the top of a bottle. They will be surprised to find that, when air cannot get into the bottle, they cannot drink through the straw. Now they can understand that air pressing on the liquid forces it up the straw when we decrease the air pressure at the top of the straw.

Air pressure will hold water in a glass dip tube when the top of the tube is closed. It forces liquids into a rubber ear syringe, and fills our fountain pens. Fill a glass with water and cover the open end with a piece of stiff paper. Hold the paper against the glass with one hand as you invert the glass. When you remove the hand from the paper, air pressure will prevent the water from coming out of the glass. A more spectacular experiment is to cover the mouth of a milk bottle with a piece of window screen. Pour water through the screen until the bottle is full. Hold one hand over the screen as you invert the bottle, then carefully remove the hand from the mouth of the bottle. See if children can explain why the water won't come out of the bottle.

A plumber's force cup will illustrate how much air presses on a relatively small surface. With it, they can lift stools and tables off the floor, or let two children try to pull two of them apart when they are pressed tightly together. Stack several glass plates wet with water together, then try to pull them apart. Air pressure holds them tightly together.

Sometimes children bring up the question, "What would happen if things like jars and cans were really empty." The varnish can experiment will show that air can exert a great pressure. Put about a half inch of water into a clean varnish can that can be tightly sealed. Put the can on a hot plate until steam comes out for a few minutes. Explain to the children that the steam is taking the place of the air

in the can. Then take the can off the hot plate and put on the cap or cork securely. As the steam inside the can begins to condense, a partial vacuum is formed. The air pressure outside the can crumples it together.

An easier experiment children can do to show that air has pressure is putting the egg into a milk bottle. Hard boil an egg that is a little larger than the mouth of a quart milk bottle. Carefully remove the shell so that the egg is intact. Now ask children to try to push the egg into the bottle without breaking the egg. They will see that air in the bottle prevents the egg from going in. Wet the egg first so it will slip easily. Then light a small piece of paper or a folded paper straw and drop it into the bottle. Place the egg, small end down, over the mouth of the bottle. When the flame goes out, the external air pressure forces the egg to "plop" into the bottle. To get the egg out, first rinse out the bottle with water. Then hold the bottle upside down with the egg in the neck of the bottle, small end down. With the bottle held tightly against your lips, blow air past the egg into the bottle. When you stop blowing, the increased air pressure inside the bottle blows the egg out.

Air pressure has a very direct effect on weather conditions. Children wonder how clouds can form high up in the air. The cloud tube experiment will show how a decrease in air pressure will result in a corresponding decrease in temperature and the formation of clouds. Use a one half inch diameter glass tube about 30 inches long. Put a tight fitting cork on one end of the tube. Wet the inside of the tube with water. Push another cork into the other end of the tube. This cork must slide through the tube, but be tight enough to prevent air inside the tube to escape past it. With a wood dowel rod, push this cork up into the tube toward the closed end. This will compress the air inside the tube. As the air is compressed, its temperature rises and it absorbs moisture. When the pressure becomes great enough, the cork on the end will be blown out. As this happens, the air inside the tube expands, its temperature drops, and a cloud forms in the top end of the tube. Pushing the cork on up pushes this little cloud into the air where it disappears. This experiment will help children to understand that as air rises, it gets colder and the water in the air condenses to form clouds.

There are a great number of other experiments that will give children experiences that will help to develop an understanding of air, how we use it, and how it affects the environment in which we live. The following books have many more suggested experiments about air that teachers of science will want to use to make science concepts fun for children to learn.

CRAIG, GERALD S., *Science for the Elementary School Teacher.*
CRAIG, GERALD S. and BRYAN, BERNICE C., *Science Near You.*
CRAIG, GERALD S. and DANIEL, ETHELEEN, *Science Around You.*
LUNDE, CARLETON J., *Science Experiences With Home Equipment.*
PARKER, BERTHA M., *Our Ocean of Air.*
PARKER, BERTHA M., *The Air About Us.*

ILLINOIS STATE NORMAL UNIVERSITY

ANNOUNCES

THE NINTH ANNUAL CONFERENCE

ON

THE TEACHING OF MATHEMATICS—ELEMENTARY AND SECONDARY LEVELS

General Theme: The Flow of Mathematical Ideas

Time: April 28, 1956, from 9/00 A.M. to 3/00 P.M. with a social hour following the conclusion of the afternoon session.
Place: Campus of Illinois State Normal University.
Speakers: Dr. Harold P. Fawcett and Dr. Herbert F. Spitzer.
Dr. Harold P. Fawcett, Chairman, Department of Education, Ohio State University, will address the secondary teachers. The title of his address is: "The Flow of Mathematical Ideas."
Dr. Herbert F. Spitzer, Professor of Education, The State University of Iowa, will address the elementary teachers. The title of his address is: "Arithmetical Materials of Instruction Today."

Following these principal addresses, there will be group discussions of interest to teachers on each level: beginners, intermediate, upper grades, and high school. Each of these discussions will follow the basic theme of the conference.

We anticipate an outstanding conference, and extend to you a personal invitation to attend its sessions.

CLYDE T. MCCORMICK, *Chairman*
1956 Mathematics Conference

A NEW SOUND FILM

"What Makes a Boy?" a 16 mm. black and white sound film based on and with quotations from Louis Redmond's book "What I Know About Boys," has been produced by United States Rubber Co.

The new film depicts in nostalgic style the sometimes bewildering but lovable nature of boys. It is now being offered exclusively to television stations as a public service. After Jan. 1, 1956, it will be available to civic clubs, church groups, women's clubs and other adult organizations free of charge. Its running time is 14 minutes.

"What Makes a Boy?" can be borrowed by writing to Public Relations Department, United States Rubber Co., 1230 Avenue of the Americas, New York 20, N. Y., or the nearest film exchange of Modern Talking Picture Service, Inc.

Junior-Sized Telescope, patterned after the world's largest professional units, has a special optical system that makes the craters on the moon visible. The telescope is 18 inches long and has a three-inch tube and a highly polished reflecting mirror. A twin lens eyepiece is set at top for easy observation.

PUBLIC PARTNERSHIP IN SCIENCE GUIDANCE

Samuel Ascher
Detroit, Michigan

and

Philip Nichamin
Los Angeles, Calif.

Most modern school systems now include on their staffs, a corps of well-trained and well-qualified counselors who know their job and are battling against great odds to do it efficiently. It is certainly not the fault of the counselors that so many of our young people are still suffering from a lack of proper guidance in their school life and in preparation for their careers. With the shortage and predicted shortage of scientists much of the counseling for science careers has been gradually falling on the shoulders of the science teachers.

The authors studied hundreds of specific instances in which children have been penalized because of inadequate counseling in school, and situations in which the parents of these children were not sufficiently informed to be of any help. Parents must play a larger role in the guidance program, and it is the obligation of professional educators to explain frankly to the people in the community the need for an expanded and improved guidance program if we want to get the scientists we need.

From a large number of case histories of students who have been victims of serious errors in their curriculum planning, just a few have been selected to demonstrate a point. These clearly illustrate the deplorable waste of effort on the part of both the school and the students. However such loss of time and effort is not the only consequence; the morale of these students is also damaged, a factor which partly explains the widespread cynicism about schools, education and science careers which the young people carry over into their adult life. This brutal fact of educational life cannot be evaded: children who receive little or no direction in choosing their curricula are seriously handicapped.

Charles G. is an 18 year old senior at an excellent academic high school. A tutor was recently employed by his family to help him in advanced algebra, which is strictly a college preparatory subject. The boy's I.Q. as given on his official record is C. He has failed repeatedly throughout his high school career, and recently he was advised by a nearby college that his credits would not qualify him as a matriculated student. The tutor found that Charles was exceedingly weak even in basic algebra. As for advanced algebra, he hadn't the

slightest idea about the subject. Despite his inability to master the required studies, he was still pursuing the regular college curriculum.

Had his abilities been properly assessed, Charles would not now be facing a serious dilemma. Entrance into a recognized college (which his family could easily afford) is now out of the question. Furthermore, the boy is completely disillusioned by repeated failures. He has lost respect for schooling in general. He missed much of what he might have gained from the school's many offerings. In spite of his average ability he might have chosen a scientific vocation which could have released a more capable man for a position which needed him.

Walter N. was about 17 years old when he found it necessary to seek help in several subjects. His parents were particularly eager that he go to college. It became apparent, however, that Walter had no aptitude whatever for college-level subjects. Those courses which might be described as having "mind-training" or disciplinary value were particularly bothersome to him. The fact that Walter was deficient in not just one, but several, academic subjects is evidence in itself that he was continually misplaced; at no point in his career was there any recognition of his inadequacy. Not only was this harming Walter but his experiences undoubtedly influenced some of his friends who might have chosen science and math courses as part of their curricula.

These cases bear analysis to understand how and why they developed as they did. First, let us examine what happened before these students entered high school. Let us ask ourselves these pertinent questions: (1) What were the criteria for classifying the students? (2) How was it possible for so many errors to creep in? (3) How does this involve science education?

Investigation revealed the following information: Classification is based on two or three *group* tests given at intervals in the elementary grades. Even without questioning the validity of these tests, we must acknowledge that they cannot accurately predict the potentialities of a particular child. As a result, children are too often assigned to a curriculum for which they have little aptitude. It is in these grades many basic preferences for certain subjects are formed.

In the intermediate schools, from which the children are to be channeled into specific high school curricula, the counseling situation is far from desirable. Here one finds usually one, or at the best two counselors for an entire school population of 2000 or more students.

Even in the high schools the number of students per counselor ranges from 400 to 600. These counselors are required to maintain voluminous records concerning their students. Practice almost always

proves that the counselors devote most of their time to clerical duties and find very little time for counseling. It is not unusual for a student to complete the high school period with but one or two brief interviews with his counselor. How many science teachers realize the scientific potential slipping by? Innumerable science teachers are helping to pull in the counseling slack, but undoubtedly not enough.

We must also ask ourselves honestly whether our curricula are always what we label them. If, for example, a student is found to be best suited for a "general" course, with a minimum of science and mathematics, what real meaning does this designation have? Further, what assurance do we have that a so-called "college preparatory course" really prepares a student for college or a professional scientific career? We are currently witnessing tremendous changes in entrance requirements in many leading colleges; no doubt these relaxed entrance requirements are evidence of a new trend. Although it is not within the scope of the present report to deal with the problem we must recognize a new challenge in giving guidance to our college preparatory students, particularly if we want them to choose a career in science. Many preliminary college science courses are reviews of high school science.

What about the people in the community in relation to the subject of counseling and school curriculum? No doubt there is a vague, unexpressed awareness of the need for testing the value of our school offerings. As with all matters of public interest, no real progress should be expected until the issue is sharply focused in the public mind. It is the task of educators who are most intimately involved in such matters to awaken public interest in curriculum analysis and proper guidance of their children.

The relationship of a merchant and his customers parallels the problem under discussion. The wise merchant studies the needs and interests of this customers. Likewise, the educational profession must study the needs and interests of the American public. One of the best ways to do this is bring the parents of our children into the discussion and planning. We must be frank about our difficulties and shortcomings. Parents must become well-informed about our testing methods, the whys and wherefores of the curricula and their contents, the real meaning of the I.Q., the significance of marks, and the opportunities in the various scientific fields.

If such a course is followed, if we take pains to transmit and translate all matters relating to counseling to the people, we can convert them from "customers" to active partners in the task of planning wisely the educational and vocational future of our youth.

PROBLEM DEPARTMENT

CONDUCTED BY MARGARET F. WILLERDING
Harris Teachers College, St. Louis, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to Margaret F. Willerding, Harris Teachers College, St. Louis, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solution should observe the following instructions.

1. Solutions should be in double spaced typed form.

2. Drawings in India ink should be on a separate page from the solution.

3. Give the solution to the problem which you propose if you have one and also the source and any known reference to it.

4. Each solution or problem for solution should be on a separate page.

In general, when several solutions are correct, the ones submitted in the best form will be used.

2479. *Proposed by W. R. Utz, Columbia, Mo.*

Given a quantity of liquid containing a_1 and b_1 per cents of two chemicals and another quantity of liquid containing, respectively, a_2 and b_2 per cents of the same chemicals contained in the first liquid. Show that a liquid can be had by mixing appropriate quantities of the two given liquids to secure, respectively, x and y per cents of these chemicals when, and only when, (x, y) is a point in the x, y-plane on the segment joining the points (a_1, b_1) and (a_2, b_2).

Solution by the proposer

Let u and v, respectively, denote amounts of the two given liquids. It is possible to effect the desired mixture when, and only when, the equations

$$a_1u+a_2v=x(u+v)$$
$$b_1u+b_2v=y(u+v)$$

have a solution $u, v \geqq 0$.

These equations are equivalent to

$$\begin{aligned}(a_1-x)u+(a_2-x)v&=0\\(b_1-y)u+(b_2-y)v&=0.\end{aligned} \tag{1}$$

Upon examining the coefficients of u, v in (1) it is clear that we must have

$$\begin{aligned}\min\,(a_1, a_2)\leqq x\leqq \max\,(a_1, a_2),\\ \min\,(b_1, b_2)\leqq y\leqq \max\,(b_1, b_2)\end{aligned} \tag{2}$$

since we must have $u, v \geqq 0$.

The equations (1) have a non-trivial solution when, and only when,

$$\begin{vmatrix} a_1-x & a_2-x \\ b_1-y & b_2-y \end{vmatrix}=0.$$

However, this is clearly the equation of the line joining (a_1, b_1) and (a_2, b_2) which, combined with (2), gives the desired result.

A solution was also offered by Richard H. Bates, Milford, N. Y.

2480. *Proposed by Brother Felix John, Philadelphia, Pa.*

Derive a formula for the sum of all the permutations of the n numbers $1, 2, 3, \cdots, n$ taken all at a time.

Solution by Arlington Fink, Waverly, Iowa

Arrange all the permutations as in arithmetic addition. There will then be ${}_NP_N$ rows and n columns. A column will contain each integer the same number of times and the frequency is ${}_NP_N/N$. The sum of a column will then be

$$1\cdot\frac{{}_NP_N}{N}+2\cdot\frac{{}_NP_N}{N}+3\cdot\frac{{}_NP_N}{N}+\cdots+N\cdot\frac{{}_NP_N}{N}=\frac{{}_NP_N}{N}\sum_{i=1}^{n} i.$$

The sum of the entire array will then be

$$1\cdot\frac{{}_NP_N}{N}\sum_{i=1}^{n} i+10\cdot\frac{{}_NP_N}{N}\sum_{i=1}^{n} i+100\cdot\frac{{}_NP_N}{N}\sum_{i=1}^{n}\ i+\cdots 10^{N-1}\cdot\frac{{}_NP_N}{N}\sum_{i=1}^{n} i=\frac{{}_NP_N}{N}\sum_{i=1}^{n} i\sum_{K=1}^{n} 10^{K-1}.$$

Since

$${}_NP_N=N!,\quad \sum_{i=1}^{n} i=\frac{N}{2}(N+1),\quad \text{and}\quad \sum_{k=1}^{n} 10^{k-1}=\frac{10^N-1}{9}.$$

The formula for the required sum becomes

$$\frac{(N+1)!(10^N-1)}{18}.$$

A solution was also offered by Richard H. Bates, Milford, N. Y. and the proposer.

2481. *Proposed by Laverne Clark, Sac City, Iowa.*

The Hammond Organ has nine drawbars. Each drawbar may be drawn out to eight degrees of expression. How many combinations are possible using all drawbars to the various degrees of expression?

Solution by J. Byers King, Denton, Md.

The Hammond Organ with which I am familiar has four sets of drawbars, nine in each set, with eight degrees of expression and a zero, or no sound position on each. Two sets of these drawbars control each of the two keyboards. There are also other keys or stops at the left of the keyboards. The one to which Mr. Clark refers in his problem does not seem to be the same, so I shall give my solution to his problem according to his statement of it, and according to my understanding of the organ.

Since each drawbar has 8 degrees of expression and also a zero position, that makes 9 positions of each drawbar. A sound will be produced if any *one* of the drawbars is pulled out. No sound will be produced if all drawbars are on zero. Since he asks for all possible combinations, without regard to how well they would sound, I would say that the solution would be 9^9-1 or $387{,}420{,}489-1 = 387{,}420{,}488$ combinations.

2482. *Proposed by Edward C. Varnum, Clyde, Ohio*

Two opposing armies containing a and b men respectively fire one round in a given unit of time. The ratio of the number of men killed to the number of shots fired is r. The army of b men is destroyed in n units of time. Express n in terms of a, b, r and also express the number remaining alive in the first army.

Solution by the proposer

At the end of the first round, there remains $b-ar$ men in the second army. At the end of the next, $b-ar-r(a-br)$ which simplifies to: $b-2ar+br^2$. Continuing in like manner, at the end of the third round there remains $b-3ar+3br^2-ar^3$. We see that the coefficients of the expansion of $(1+r)^n$ are appearing and that all odd terms contain $+b$ and all even terms contain $-a$. Factoring and generalizing: $b(1+{}_nC_{n-1}r^2+{}_nC_{n-3}r^4+\cdots)-a({}_nC_nr+{}_nC_{n-2}r^3+\cdots)$ are left in the secondary army after n rounds. Set this equal to zero and solve for b/a.

Let us turn now to the formula for the sum of two hyperbolic tangents: $\tanh(x+y)=(\tanh x+\tanh y)/(1+\tanh x\cdot\tanh y)$. By setting $x=y$, and continuing to derive multiples of x, we arrive at the following:

$$\tanh(nx)=({}_nC_n\tanh x+{}_nC_{n-2}\tanh^3 x+\cdots)/(1+{}_nC_{n-1}\tanh^2 x+{}_nC_{n-3}\tanh^4 x+\cdots)$$

Setting $\tanh x=r$, and substituting in the solution for b/a: $\tanh(nx)=b/a$; $nx=\tanh^{-1}(b/a)$; $n\tanh^{-1}r=\tanh^{-1}(b/a)$.

Thus:

$$n=\frac{\tanh^{-1}(b/a)}{\tanh^{-1}r}\cdot$$

To find the number of living victors, let $m=(1+{}_nC_nr^1+\cdots)$ and $d=({}_nC_nr+{}_nC_{n-2}r^3+\cdots)$. Then $bm-ad=0$. But $am-bd$ would equal $am+ad-bm-bd=(a-b)(m+d)$. However, $m+d=(1+r)^n$. Thus there survive in the first army $(a-b)(1+r)^n$.

2483. *Proposed by Norman Anning, Alhambra, Calif.*

Give a method for finding all kinds of parallelograms having integral sides and integral diagonals. Such things exist. For example here are two kinds:

Sides	Diagonals
8, 9	11, 13
11, 13	16, 18
16, 18	22, 26

Solution by Joan Doersching, Milwaukee, Wis.

If the diagonals of the first parallelogram are equal to the sides of a second, the diagonals of the second parallelogram equal twice the sides of the first. The diagonals of a third will be equal to twice the length of the sides of the second. This process can be continued indefinitely.

2484. *Proposed by Brother Felix John, Philadelphia, Pa.*

If in triangle ABC, the circumradius, R, equals t_c, the bisector of the angle C, and angle A equals angle B, find the number of degrees in angle C.

Solution by Joseph Kennedy, Madison, Wisconsin

Since angle A equals angle B, t_c is the perpendicular bisector of AB. Therefore the circumcenter falls on t_c and $AB=2t_c$. Thus t_c divides triangle ABC into two isosceles right triangles and angle C is at right angle.

Solutions were also offered by Richard H. Bates, Milford, N. Y., Lottie Keenan, Bull's Head, N. Y.; Jo Anne Kerris, Clarkston, Mich.; Walter R. Warne, St. Petersburg, Fla.; Theresa Wick, Milwaukee, Wis.; and the proposer.

STUDENT HONOR ROLL

The Editor will be very happy to make special mention of classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

Editor's Note: For a time each student contributor will receive a copy of the magazine in which his name appears.

The Student Honor Roll for this issue appears below.

2481. *Richard J. Kerslacke, Caroline High School, Denton, Md.*

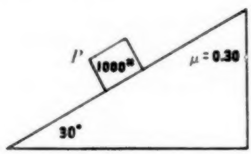
PROBLEMS FOR SOLUTION

2503. *Proposed by Brother Felix John, Philadelphia, Pa.*

In an equilateral triangle, the circumradius R equals twice the inradius r. Given, in triangle ABC that $R=2r$. Prove, if possible, that the triangle is equilateral.

2504. *Proposed by Julius Sumner Miller, New Orleans, La.*

A homogeneous cubical block rests on the incline as shown. The coefficient of friction is 0.30. A force P is applied at the upper edge of the block and parallel to the plane. Will the block slide or tip?



2505. *Proposed by Leon Bankoff, Los Angeles, Calif.*

The diameter AC of a circle O is one of the diagonals of a cyclic quadrilateral $ABCD$. If H, H' are the orthocenters of triangles ABD, BCD respectively, show that quadrilaterals $BH'DH$ and $ABCD$ are congruent.

2506. *Proposed by Dwight L. Foster, Florida A. & M. College.*

If the equations

$$ax+by=1$$
$$cx^2+dy^2=1$$

have only one solution, prove that

$$a^2/c+b^2/d=1 \quad \text{and} \quad x=a/c, \quad y=b/d \cdot$$

2507. *Proposed by Brother Felix John, Philadelphia, Pa.*

Prove the identity

$$\frac{\sin^4 x+\cos^4 (x+30°)+\sin^4 (x+60°)}{\sin^2 x+\cos^2 (x+30°)+\sin^2 (x+60°)}=\frac{3}{4}.$$

2508. *Proposed by Brother Felix John, Philadelphia, Pa.*

In the triangles ABC and $A'B'C'$, angles C and C' are supplementary, and sides c and c' are equal. If the perimeters of the triangles are equal, find the ratio of their areas.

MNEMONIC DEVICES WANTED

Prof. Will S. DeLoach, Head of the Chemistry Department of Catawba College, Salisbury, North Carolina, is making a collection of mnemonic devices that have been found useful in the teaching of chemistry. If you know of any, please write to him giving references, if they have been published. He would like to know the author and publisher, if they have been published, and will give the proper credit when his list is published.

BOOKS AND PAMPHLETS RECEIVED

ANALYTIC GEOMETRY AND CALCULUS, by Thurman S. Peterson, Ph.D., *Professor of Mathematics, Portland State College, Portland, Oregon.* Cloth. Pages ix+456. 14.5×23.5 cm. 1955. Harper and Brothers, 49 East 33d Street, New York 16, N. Y. Price $5.50.

GUIDE TO THE STARS, by Hector Macpherson, M.A., Ph.D., F.R.S.E., F.R.A.S. New and Revised Edition. Cloth. Pages x+144+6 plates. 11.5×18 cm. 1955. Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price $2.75.

THE TEACHING OF ELECTRICITY WITH SPECIAL REFERENCE TO THE USE OF M.K.S. UNITS, by John Murry. Cloth. Pages xii+135. 13.5×21.5 cm. 1954. John Murry (Publishers) Ltd., Albemarle Street, W., London, England. Price 10s. 6d.

ANALYTIC GEOMETRY, Fifth Edition, by Clyde E. Love, Ph.D., *Professor Emeritus of Mathematics in the University of Michigan,* and Earl D. Rainville, Ph.D., *Professor of Mathematics in the University of Michigan.* Cloth. Pages xiv+302. 13×20.5 cm. 1955. The Macmillan Company, 60 Fifth Avenue, New York 11, N. Y. Price $4.00.

FAMOUS PROBLEMS AND OTHER MONOGRAPHS, by F. Klein, W. F. Sheppard, P. A. Macmahon, and L. J. Mordell. Cloth. Pages xi+92+127+viii+71+31. 12.5×20.5 cm. Chelsea Publishing Company, 552 West 181 Street, New York 33, N. Y. Price $3.25.

THE THEORY OF GROUPS, by A. G. Kurosh. Translated from the Russian and Edited by K. A. Hirsch. Volume One. Cloth. 272 pages. 14.5×23 cm. 1955. Chelsea Publishing Company, 552 West 181 Street, New York 33, N. Y. Price $4.95.

200 MILES UP, by J. Gordon Vaeth, *Head, New Weapons and Systems Division, U. S. Navy Special Devices Center, Office of Naval Research.* Second Edition. Cloth. Pages xiii+261. 1955. The Ronald Press Company, 15 East 26th Street, New York 10, N. Y. Price $5.00.

THE SUPERIOR PUPIL IN JUNIOR HIGH SCHOOL MATHEMATICS, by Earl M. McWilliams, *Allderdice High School, Pittsburgh, Pennsylvania,* and Kenneth E. Brown, *Office of Education, Washington, D. C.* Bulletin 1955, No. 4. Pages v+57. 15×23 cm. Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Price 25 cents per copy.

CHILDREN'S BODY MEASUREMENTS FOR PLANNING AND EQUIPPING SCHOOLS, Prepared by W. Edgar Martin, *Specialist for School Furniture and Equipment, Division of State and Local School Systems.* Paper. Pages viii+113. 19.5×26 cm. 1955. Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Price 50 cents.

CREATION AND FUNCTIONING OF THE UNIVERSE, by L. W. Flack, Sr., *3215 E. 7th Street, Kansas City 24, Missouri.* Paper. 28 pages. 19.5×28 cm. 1955.

THE PRESIDENT'S REVIEW FROM THE ROCKEFELLER FOUNDATION ANNUAL REPORT 1954. Paper. Pages ix+145. 14.5×22 cm. The Rockefeller Foundation, 49 West 49th Street, New York 20, N. Y.

World Globe is made of plastic and inflated by either hand pump or lung power to a full 18-inch diameter. Colored and containing the latest geographical information, the world globe can be attached to a wrought iron stand. If dropped, it will not shatter, split, dent or lose its shape.

BOOK REVIEWS

ELECTRONS, ATOMS, METALS AND ALLOYS, by William Hume-Rothery, O.B.E., F.R.S., *Lecturer in Metallurgical Chemistry, University of Oxford, England.* Cloth. 375 pages. 13.5×21.5 cm. 1955. Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price $10.00.

How does an art become a science? The author classes metallurgy as an industrial art that may be groping but has not yet quite attained the status of a science. In this book, reporting the dialogue between an "Older Metallurgist" and a "Young Scientist," something of the program for that evolution is assessed both for desirability and difficulty.

The topics considered are presented in four sections: The Nature of an Atom; The Nature of a Metal; The Nature of an Alloy and The Structure of the Nucleus. Under the first part are found, among others, conversations on: Bohr Theory; Electron Waves, Heisenberg's Principle; Wave Mechanics; Electron Spin and Pauli's Principle. In Part II are found: Metals as Crystals; the electron in crystals and as free electrons; Brillouin zones and electron distribution; Van der Waal's forces and co-valent bonds; metals as insulators and semi-conductors. In relation to alloys: solid solutions, electron compounds and superlattice structures and interstitial compounds are treated. The section on the nucleus, in five chapters, presents the expected.

Even though a dialogue implies conversation, conversations are not necessarily non-mathematical. This author permits the "Young Scientist" to frame many of his answers to the older member in the form of equations and other mathematical forms of expression. The tie-in with the practical aspects of the topics, however, quite generally ferries the reader over such lapses with a limited lag in interest.

This book will have especial appeal to: students contemplating a career in metallurgy; metallurgists already in practice who are interested in what may be just ahead in their industry and to the teacher interested in the impact of scientific theory upon an industry emerging from the arts and crafts phase of its evolution.

The author has previously prepared: "Atomic Theory for Students of Metallurgy" and "The Structure of Metals and Alloys." The book under review attempts the aims of the two earlier books in a somewhat less formal and more readable manner.

The book has an analytical-type table of contents. There are adequate indices for both subjects and authors. Twelve of the forty five chapters are followed by "Suggestions for Further Reading." One hundred seventy one figures aid the reader in following the "Young Scientist" as he answers the "Old Metallurgist's" questions.

B. CLIFFORD HENDRICKS
Longview, Wash.

HANDBOOK OF 630-TYPE TV RECEIVERS, by Simon S. Miller, *Chief Engineer*, and Howard Bierman, *Senior Engineer.* Paper. Pages vi+194. 14×22 cm. 1955. John F. Rider, Publisher, Inc. 480 Canal Street, New York 13, N. Y. Price $3.50.

This handbook is primarily "designed for service technicians who work on receivers." It assumes a knowledge of the technical aspects of television receivers and promises to "set forth the 'hows' and 'whys' of each of the 630-type receiver sections."

It further proposes to "show the critical components, symptoms of failure, causes and remedies." To some extent to "show successful methods used in converting older sets to larger picture tubes, in adding keyed automatic gain control, in improving video gain, etc."

Its twelve chapters are listed as: "Tuners; Video I-F alignment; A G C sys-

tems; Video amplifier and D-C restorer; Sync circuits; Horizontal deflection and high-voltage section; Vertical circuits; Low voltage power supply; The picture tube and Troubleshooting charts.

There are 116 figures and diagrams, most of them for wiring circuits. There is also a four page double column index.

B. CLIFFORD HENDRICKS

PRACTICAL LABORATORY CHEMISTRY, A MANUAL FOR BEGINNERS, by Horace G. Deming, *Research Associate, Department of Chemistry, University of Hawaii.* Paper. 209 pages. 23.0×28.0 cm. 1955. John Wiley & Sons, Inc. 440 Fourth Avenue, New York 16, N. Y. Price $3.50.

Tradition seems to have established the order: first the text book then a laboratory manual to "accompany it." Critical scrutiny of those "text book companions" would often rate them rather mediocre company. The book under review has broken with that formula. It has no companion text book.

This "work book," for it is definitely more than a laboratory manual, makes a different approach. Here the laboratory part of the course is lifted to a nearer approach to parity with its text book partner.

Its contents are classified under: Preliminary (How to do it.); Laws and Principles, and a Part III, Some Important Non-metals. Metals receive no attention other than in ion form. When the sub-titles are scanned, additions to traditional offerings are found such as: Chromatography, Corrosion and Semi-micro Techniques.

Especial emphasis is given to "teaching correct technique." This section is serviced by a generous and well labelled offering of line drawings. The page order seems to imply that the student should learn correct techniques before he does any serious experiments of chemical import.

Half the page space is devoted to "Laws and Principles." No break with tradition is found here. Such exercises are usually introduced by: "We shall illustrate this law, etc." Even in this section technique is to the fore.

Users with an eye to second year chemistry will be happy to find stress on: the metric system, measurements, precision weighing, "thinking in moles," "common sense in numbers" and many numerical exercises.

The teacher is not forgotten either. The preface: introductions "to the instructor," "to the student," and a page of "general instructions," four two-page sets of "review exercises," nine appendices, and, even a two page double columned index, testify to the author's concern that the teacher is important in the course.

However, there are some questions likely to be asked by that teacher, especially if his "beginners" are also likely to be "enders" with this course. As promised, in directions to students, will such beginning students look upon this plan as "a pleasant opportunity?" This appears to be an attractive training program but is not a drill-master often impatient with the delay required for understanding? Does it not frequently happen that technicians become skilled without becoming educated?

Even so, this book warrants attention of teachers of freshman college chemistry. It has many original features that mark it as a contribution to the resources of those interested in the laboratory part of the science program.

B. CLIFFORD HENDRICKS

EXPERIMENTAL ELECTRICITY FOR THE BEGINNER, by Leonard R. Crow, *Director of Research and Development, Universal Scientific Co., Inc.* Paper. Pages xvi +284. 21.5×28 cm. 1954. Second edition. The Scientific Book Publishing Company, Vincennes, Indiana.

The purpose of this book is to contribute to a broad understanding of elementary electricity and magnetism through a series of sequentially arranged related experiments. These experiments are organized around a specially designed

type of equipment, the CROW Beginner's Experimental Kit in Magnetism and Electricity, available from the Universal Scientific Co., Vincennes, Illinois. The experiments are of an elementary nature, intended for students of elementary science, industrial arts, and physics, as well as Boy Scouts, boys and girls of 4-H clubs, hobbyists, and all teachers of elementary science.

The 194 experiments outlined in the book are grouped into 6 chapters:

1. Magnetism and Permanent magnets	54 experiments
2. Circuitry	21 experiments
3. Electromagnetism	28 experiments
4. Induction and Transformers	32 experiments
5. Bells, Buzzers, Thermostats, Switches, and Relays	23 experiments
6. Electric Motors and Controllers	36 experiments

A seventh chapter treats some applications of motors in experiments dealing chiefly with sound and optical effects.

The experiments are well graded and become more complex as the experimenter works his way through the lists. Each experiment generally deals with a single simple procedure or idea, although in some of the later experiments two different procedures are treated. Directions and explanations are definite and adequate. The many excellent figures and diagrams are clean-cut and well-labeled.

In many of the experiments, the experimenter is told what will happen and what he should observe. Often he is told how he should interpret the observed phenomena and what conclusions he should draw from them. Many teachers and experimenters, too, will feel that this approach detracts from the interest and educational value of the experiments. The electric circuits employed in these experiments use no electric meters, yet in some experiments, the author seems to imply quantitative relationships involving volts and amperes as quantities determined experimentally. In general, electrical and magnetic quantities are clearly defined and used in proper context, but in one or two cases (experiment 4–15, for example) the concepts of electrical resistance, inductance, reactance, and impedance are badly confused. This may result from an effort to simplify these rather difficult concepts for elementary presentation. While the experiments described in this book require special apparatus, nevertheless a boy or girl with a bent for experimentation would be likely to find these experiments not only exceedingly interesting but very instructive as well.

WALTER G. MARBURGER
Western Michigan College
Kalamazoo, Michigan

ROTATING ELECTRICAL MACHINERY. Paper. Pages 256. 21.5×28 cm. 1954. Published by Universal Scientific Co., Vincennes, Indiana. Price $3.50.

This book is an adaptation to civilian use of a portion of the Bureau of Naval Personnel's "Common Core" training program in Basic Electricity and Electronics. This publication includes modified Sections VI (DC Machinery) and VII (AC Machinery) of the Navy series on Basic Electricity. Experiments and demonstrations described in this book are designed to use the CROW Rotating Electrical Machinery Kit.

Specific items treated include: The CROW Electrical Machinery Kit, Elementary Generators, Magnetic Fields, Direct Current Generators, Direct Current Motors, DC Motor Starters, DC Machinery Maintenance and Trouble-shooting, Alternators, and Alternating Current Motors.

The method of developing each of these divisions consists of a thorough and concise exposition of fundamental principles involved, followed by a series of suggested demonstrations to be set up and performed by the instructor, or under his close supervision, followed in turn by directions for several experiments to be set up and performed by the different student groups.

The text of this book is simple, direct, and definite. There is ample clear explanation, but no excess verbiage. The electron flow concept of electric current, with

accompanying left hand rules for relative direction of current and magnetic field is used exclusively. Diagrams, exploded views, and pictorial illustrations are used profusely and to good effect. Considerable data regarding performance characteristics are presented in graphic charts. The student experimenter is encouraged to display his experimental data in the form of a graph wherever possible.

This book is a fine example of integration of the theoretical and the practical aspects of elementary electrical science. It should prove valuable in the basic work of trade and industrial courses in all types of secondary schools.

WALTER G. MARBURGER

STATISTICAL METHODS: THIRD EDITION, by Frederick C. Mills. Pages xviii+842. 15.5×23.5 cm. 1955. Henry Holt and Company, Inc., 257 Fourth Avenue, New York 10, New York. Price $6.90.

Of all courses in colleges and universities, those in statistics are most universally detested. With small effort on the part of the instructor they can become the dullest of memory courses. Hence, a review of a new book in statistics involves not only an examination of its contents, but a critical analysis of its possibilities for being used in an interesting way.

What aspects does a reviewer look for? There are several. Does the book emphasize the logic of statistics? Does it describe the modern statistical tools? Does it emphasize the need for interpreting statistical computations in terms of the variability of the contributing data? An affirmative reply is indicated to each of the above in light of the statement of the author that he "tried to make the text a more effective instrument for instruction in the logic and methodology of modern statistics, and a more useful hand book for the practicing statistician."

A careful examination of the book, however, indicates that it tends to emphasize an advanced computational approach to statistics rather than an introductory functional one. While examples such as discount rates of Federal Reserve Banks are frequently included, they hardly constitute a view of the logic of statistics. The use of these examples seems forced.

The use of modern statistical tools is extensive. One finds well written sections dealing with analysis of variance and covariance, the F test, analyses of time series, and multi-stage and multi-phase sampling.

As with other texts, one finds discussions concerning the errors that exist in data, but no direct emphasis on the cautious interpretation of computations that may be influenced by such errors.

In general, this book is complete, thorough and scholarly. It uses many common illustrations for the statistical computations. However, it is not a text that could be used by the novice. In order for it to serve in a functional manner, it would seem that the user should be well-grounded in elementary statistics. To those persons it will be interesting.

GEORGE G. MALLINSON

THE GOLDEN BOOK OF ASTRONOMY, by Rose Wyler and Gerald Ames. Paper. Pages 97. 26×33 cm. 1955. Simon and Schuster, 630 Fifth Avenue, Rockefeller Center, New York 20, New York. Price $3.95.

With the current interest in rockets, jets and space travel, young people are even more interested in astronomy than ever before. This well-written book on astronomy is a "gold mine" of information for young readers. It is very complete and scientifically accurate, but at the same time is written in a style that will be easily understood by intermediate-school children.

The book contains detailed descriptions of the earth, sun, moon and planets as well as explanations of such phenomena as tides, eclipses, and sky colors. There are also clear discussions of the cause of day and night, the change in seasons, and the tools used by astronomers.

Of particular appeal to most youngsters is the section at the end of the book that is devoted to space travel. It contains interesting discussions of the prob-

lems of space travel, plans for future rocket ships and space stations, and what life on the moon would be like. Most young people will be fascinated by the illustrations of proposed space suits, instruments, and space ships.

In addition to the illustrations mentioned above, the entire book is beautifully illustrated in full color paintings. The end pages are also illustrated with constellation maps of the four seasons which will be helpful in locating the common star groups.

In summary, the book contains a wealth of information on the fascinating topic of astronomy. It would be an excellent source book for a classroom, as well as a fine addition to the personal library of a young reader.

GEORGE G. MALLINSON

THROUGH THE MAGNIFYING GLASS, by Julius Schwartz. Cloth. Pages 142. 14.5×21 cm. 1954. Whittlesey House, McGraw-Hill Book Company, Inc. 330 W. 42nd Street, New York, New York. Price $2.50.

Through the Magnifying Glass presents a host of very interesting science activities for boys and girls of intermediate-school age. For any pupil interested in the field of science, this book should be a fascinating source of new ideas and information. The author outlines some facts about the selection, use and care of hand lenses and then proceeds to describe many interesting "experiments" that can be done with a simple lens.

A wide variety of objects for study are suggested. They include such things as fingerprints, crystals, plant material, animal life and photographs. In addition to outlining the method of observing the objects, the author also gives the reader a careful, detailed discussion of the scientific principles related to his observations. For example, following the instructions for observing the cellular structure of plant material, a detailed discussion is given of the functions of the various parts of a plant.

If there is any criticism of the book, it is the fact that it is so all-inclusive. It is doubtful if any but the most superior youngster would be capable of comprehending all the material that is presented. However, there are parts of the book that are suitable for the average upper-elementary or junior-high pupil.

In addition to the author's excellent and complete discussions, the book is further enhanced by the clever, interesting illustrations by Jeanne Bendick. Miss Bendick is well known for her art work in children's science books. The book should be an excellent addition to the science shelf in a classroom, or a most welcome gift for the youngster who is interested in science.

GEORGE G. MALLINSON

NOT ONLY FOR DUCKS, by Glenn O. Blough. Cloth. Pages 48. 18.5×26 cm. 1954. Whittlesey House, McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York, New York. Price $2.25.

Not Only for Ducks is the story of rain as seen through the eyes of a young farm boy. At first Mike is very disturbed by the occurrence of rain because it prevented him from playing outside and flying his kite. However, after a long, dry summer that almost ruined the farm crops, he became aware of the great importance of rain in the lives of all living things.

Threaded through the story of Mike and the farm are well-written, scientifically accurate descriptions of the uses of water for drinking, washing, and manufacturing; the importance of rain in the germination of seeds; and the importance of water to fish and amphibians. In addition there is a brief, elementary description of the cause of rain and the importance of gravity in distributing the rainfall.

The book contains a great deal of science material, but it is presented in a context that should be of great interest to most young children. In addition to interesting story, the book is also very appealing because of its colorful, clear illustrations by Jeanne Bendick. The book should be an excellent addition to any elementary-school library or classroom.

GEORGE G. MALLINSON

CENTRAL ASSOCIATION
OF
SCIENCE AND MATHEMATICS TEACHERS

REPORT OF THE FIFTY-FIFTH CONVENTION

NOVEMBER 24–26, 1955, SHERATON-CADILLAC HOTEL, DETROIT, MICHIGAN

I. BOARD OF DIRECTORS MEETING

THURSDAY, NOVEMBER 24, 1955, 4:00 P.M. AND 7:30 P.M., SHERATON ROOM

Roll Call: Officers: Pella, Junge, Soliday, Terhune; Past-President Price, Board Members: Gross, Huffer, J. Mallinson, Otto, Panush, Spangler; *Journal* Editor Warner, Assistant Journal Editor G. Mallinson, *Yearbook* Editor Shetler; Committee chairmen Gibb and Lankton.

President Pella reported that Mr. Edwards is in the hospital in Ann Arbor, having undergone surgery. In view of Mr. Edwards' work in CASMT previous to the convention and in view of his efforts in preparation for this convention, the Board of Directors voted to send flowers and a card conveying our best wishes and appreciation.

Minutes of May Board Meeting: The reading of the minutes of the previous board meeting was dispensed with and the minutes were approved as printed.

Review of Association Affairs: President Pella called attention to the fact that the Association is in the best shape financially that it has been in some time, the past year showing a profit of about $2,000. He expressed his thanks for the hard work done by the people in the Detroit area in preparation for this convention.

Local Arrangements: Charlotte Junge reported in the absence of Mr. Edwards. She reported that the Metropolitan Detroit Science Club had donated $25 and the Metropolitan Detroit Mathematics Club $125 for convention expenses, and that the College of Education of Wayne University had given $50 for dinner expenses. Plans for the Friday night program were announced.

Emeritus Memberships: In the report sent by Mr. Bos four names were proposed for emeritus memberships: Mr. A. J. Conrey, Laramie, Wyoming; Mr. J. M. Kurtz, Chicago, Illinois; Mr. W. A. May, Indianola, Indiana; and Mr. John A. Smith, Chillicothe, Ohio.

AAAS Report: In Mr. Edwards' absence, Mr. Mallinson reported on the meeting of the Cooperative Committee in Washington.

Historian's Report: Copies of the historian's report, dealing with the historical development of the Treasurer-Business Manager's job, were distributed. Mr. Soliday was instructed to prepare a statement regarding the duties and responsibilities of the office of the Treasurer-Business Manager for the approval of the Board.

Next discussed was the need for clarification of the wording of the motion of November, 1954, concerning the salary of the Treasurer-Business Manager. It was voted that the word "annual" be stricken from the statement of the Treasurer-Business Manager's salary as stated in the minutes of November, 1954, and that a note be inserted in the official minutes directing the readers' attention to this change.

Editor's Report: Dr. Warner called attention to the need for a new Biology editor, a Conservation editor, a high school editor for Chemistry, and a college editor for Physics.

Journal Committee: In Mr. Bos' absence, President Pella presented his report, copies of which had been prepared by Mr. Bos and were distributed to those present.

Treasurer's Report: According to the audit, the profit from operation of the last fiscal year was $1,895. Mr. Soliday noted that income from each item of income was greater than had been considered likely in the budget. He remarked that basic printing costs are up seriously, but part of this increase is due to print-

ing 200 more copies of the *Journal* than formerly.

Membership Committee: A copy of the report of the membership committee was submitted by Mr. Lankton for the files of the secretary.

Policy and Resolutions Committee: Miss Gibb submitted a report of the survey made in May, 1955, a questionnaire to be used at this convention for evaluating this year's program, and a study of CASMT programs for the years 1946–1955. Copies of these three reports were filed.

Yearbook: Copies of the financial statement for the 1955 *Yearbook*, showing a profit of $149.47, were distributed by Mr. Shetler. A report was also filed by the *Yearbook* editor on "Activities of Managing Editor of CASMT Yearbook." This report gives a list of the current practices as compiled by the present editor. It was voted that the *Yearbook* editor be included as a member of each hotel selection committee. The *Yearbook* editor and business manager were authorized to establish prices for advertising and exhibiting for the 1956 convention.

New Business: President Pella asked for consideration of the question as to how CASMT can participate in the improvement of the teaching in science and mathematics. The question was raised as to whether recruitment of students in high school science and mathematics classes was intended or in-service training of teachers, the latter being the purpose of this organization since its founding. After much discussion, no decision was reached or action taken.

It was voted that the historian's report for 1956 concern the duties of the secretary.

The meeting adjourned at 10:20 P.M.

II. ANNUAL BUSINESS MEETING

SATURDAY, NOVEMBER 26, 1955, CRYSTAL BALLROOM

The meeting was called to order by President Pella at 10:30 A.M.

President Pella announced that the books of Dr. Carver on "Distance and Azimuth Computations" are available on loan by writing to the Association secretary, Miss Virginia Terhune, Proviso Township High School, Maywood, Illinois.

It was moved, seconded, and carried that the reading of the minutes of the previous business meeting be dispensed with since they were published in the March, 1955, issue of the *Journal*.

For consideration of the proposed revision of the By-Laws, copies were distributed to those present. It was moved by Oswald, seconded by Renner, that the amendments be considered en masse. In the discussion of the motion, Mr. Price called attention to the discrepancy in the wording in Article III, Section 1, and Article III, Section III, in Section 1 the officers being designated as "a President, a Vice-President, a Secretary, a Treasurer and Business Manager, an Editor of the *Journal*, and an Historian": and in Section III a "Secretary-Historian" is mentioned in two places. Mr. Price moved that Section 1 be written to conform with Section III. Seconded by Ayre. Carried. It was then pointed out by Mr. Peak that the membership could not thus change this part of Article III, Section 1, since it was not a part of the proposed amendments twice published in the *Journal*. It was then moved by Mr. Leonard that the action just taken be rescinded. Seconded and carried. It was moved by Mr. Huffer that the hyphen between Secretary-Historian be preplaced by the word "and," to make Article III, Section III read "Secretary and Historian" in the two places when that occurs. Seconded, and defeated. The original motion to consider the By-Laws en masse was then voted upon and defeated. Mr. Read then moved the adoption of Article 1, Section III. Seconded and carried. Mr. Read then moved the adoption of Article II: Section 1. Seconded and carried. Mr. Read then moved that we refer to the proper committee Article III, Section 1 and Section III for elimination of the conflict in wording. Motion was seconded and carried. Mr. Read then moved the adoption of Article III: Section IV as proposed, deleting the sentence "He shall also act as Business Manager of the *Journal*." Seconded and carried.

President Pella then announced that emeritus memberships had been awarded to the following persons: Mr. A. J. Conrey, Laramie, Wyoming; Mr. J. M. Kurtz, Chicago, Illinois; Mr. W. A. May, Indianola, Indiana; and Mr. John A. Smith, Chillicothe, Ohio.

President Pella announced that the 1956 convention city would be Chicago, Illinois.

Mr. Peak, reporting for the nomination committee, presented the following slate of officers for 1956:

President: Fred Leonard, Redford High School, Detroit, Michigan

Vice-President: James Otto, Washington High School, Indianapolis, Indiana

Board of Directors, terms to expire in 1958:

Edward Bos, Proviso Township High School, Maywood, Illinois
Sister Mary Evarista, Mercy High School, Chicago, Illinois
Cecil Read, University of Wichita, Wichita, Kansas
F. Lynwood Wren, Peabody College, Nashville, Tennessee

When nominations from the floor were called for Mrs. Jacqueline Mallinson nominated for President Charlotte Junge.

It was then moved, seconded, and carried that the vote be taken on the proposed slate for the office of Vice-President and for Board of Directors. It was moved by Allen Meyer, that the candidates for the Board of Directors as nominated by the committee be elected. Seconded and carried.

It was moved by Price that Mr. Otto be elected as vice-president. Seconded and carried. A motion was then made that the vote for President be taken on secret ballot. Seconded and carried. President Pella appointed two members to act as clerks.

While the votes were being tabulated President Pella in a short speech expressed his sincere gratitude to the membership of CASMT for the fine cooperation and help given him during the past year.

Mr. Glenn Ayre moved that the Board of Directors instruct the Nominating Committee to present two names for each elective office and for the Board of Directors, their names to be printed in the October issue of the *Journal*, and ballots to be printed. Seconded, A motion was made to amend by substituting "*Yearbook*" for "October issue of the *Journal*." Mr. Huffer then moved an amendment to the motion of Mr. Ayre to the effect that it be interpreted as a recommendation to the Board of Directors rather than as a mandate. Motion seconded by McCormick, and carried. The motion as amended was then passed.

Mr. Meyer, acting as clerk, then announced that as a result of the vote for President, Dr. Charlotte Junge was the newly elected President of the Association.

Mr. John Mayor spoke briefly on the Science Teaching Improvement Program.

The meeting was adjourned at 11:15 A.M.

III. BOARD OF DIRECTORS MEETING

SATURDAY, NOVEMBER 26, 1955, 1 P.M., SHERATON ROOM

Roll Call: Pella, Junge, Price, Soliday, Warner, Shetler, Spangler, Read, Wren, McCormick, Gross, Kennedy, Panush, Huffer, Takala, G. Mallinson, J. Mallinson, Otto, and Terhune.

The meeting was called to order by President Pella, who then read the report of the Place of Meeting Committee. This committee recommended Chicago for the 1957 meeting, and asked that for 1958 the Board consider either Indianapolis or Cincinnati. Mr. Otto was asked to investigate the question as to whether or not Indianapolis would like the convention in 1957 and to report at the May Board Meeting.

In the discussion of the appointment of an assistant business manager, Mr. Soliday suggested that Mr. John Kennedy, serving as the new chairman of the membership committee, work at some of the work of an assistant either in getting

additional advertising for the Journal or additional subscriptions and use this period to see if he is interested in assuming the job of assistant business manager later. It was moved by McCormick, seconded by Takala, that Mr. Soliday be empowered to enter into negotiations with Mr. Kennedy concerning phases of business management of this Association. Carried.

Mr. Pella extended his thanks to the Board for the assistance and cooperation given in the past year. He then introduced the new Board members: Dr. Cecil Read and Dr. F. Lynwood Wren; Sister Evarista was unable to be present.

Mr. Pella then turned the meeting over to the newly-elected president, Dr. Charlotte Junge.

The first item of business considered by the new Board was the proposed change in method of nomination of the elected officers and Board Members. After much discussion it was moved by Wren, seconded by McCormick, that this problem be thought over thoroughly and discussed at the May Board meeting.

It was moved by Read to amend the above motion by including the statement that the President appoint a committee to study practices of other organizations concerning their elections.

Seconded by J. Mallinson, and carried.

The original motion, as amended, was then passed.

It was moved that a resolution be passed designating the River Forest State Bank as the depository of the funds of the Association and authorizing the business manager to disburse such funds with the cosignature of the president. Seconded and carried.

The first Saturday in May was designated as the date for the next Board meeting.

The meeting was adjourned at 3 P.M.

Respectfully submitted,
VIRGINIA TERHUNE, *Secretary*

N.J. SCIENCE TEACHERS CELEBRATE 50TH ANNIVERSARY

With Governor Robert B. Meyner cutting the birthday cake and Dr. Glenn O. Blough delivering the main address, the N.J. Science Teachers Association celebrated its 50th anniversary at a luncheon on November 10th in Atlantic City. Over 150 teachers were present including 13 past presidents who were guests of the association. Governor Meyner presented them with scrolls for their service to science education and their leadership in the N.J. Science Teachers Association.

On Friday, November 11th large groups of teachers attended the sectional meetings. Miss Grace Koerner conducted a meeting attended by over 300 elementary teachers on a "How to do it" section. Dr. Victor Crowell and Prof. Ivan Richardson conducted a session on how conservation can be taught better at the elementary level.

Carmine Sippo directed the General Science meeting. Charles Lacefield, Irvington High School sophomore demonstrated his award winning project, New-clear Energy Going to Sea." Films recently purchased by the State Museum on the recommendation of the N.J. Science Teachers Ass'n. were also previewed.

Grace Dick conducted the Biology section where Dr. Abraham Weckstein spoke on "Brass Tacks for the Biology Teacher." The Physics-Chemistry section saw demonstrations of student projects as well as those by leading teachers. These demonstrations were conducted by Rev. Lucien Donnelly OSB, Delbarton School, Morristown, Kennedy Carpenter, Butler High School, Alex Johnson, Verona High School and John Wright, Chatham High School.

Harold Hainfeld, Roosevelt School, Union City was in charge of the program. At the luncheon meeting he presented Governor Meyner with a certificate for his efforts in informing the people of New Jersey about problems on conservation through his television program "Report to the People."

PUPILS IN EXCESS OF NORMAL CAPACITY

Almost 2.4 million pupils were reported as in excess of the normal capacity of the accessible publicly-owned school plants in use. This number was a quarter of a million less than the number reported a year ago. That the reduction was not general is indicated by the fact that 18 States showed an increase in excess pupils.

The effects of the extensive school construction program carried out during the 1954–55 school year are reflected in an over all reduction in the existing backlog of excess pupils during a period of rising enrollments. Thus, while 9% of the total enrollment was reported as in excess of normal capacity in the fall of 1954, the present proportion has been reduced to 7.8%.

From a Report of the U. S. Department of Health, Education, and Welfare

A CHEMISTRY PROFESSOR SUMMARIZES

"1. A tightening of the scholastic requirements in the college preparatory courses of the secondary schools. I do not mean to make them terribly difficult but to emphasize thinking, interpretation, problem solving, reasoning, the application of mathematics and principles rather than so much memorization.

"2. A saneness of college chemistry text with basic fundamental material which is reasonably expressed and challengingly presented in a size book that an average student can study, absorb and comprehend.

"3. Presentation of material to the good average student so that with conscientious study there is reasonable assurance of passing the course.

"4. A better preparation of more and better teachers of chemistry *on all academic levels.*"

—*Chemical News*

FELLOWSHIPS IN CHEMISTRY

Saint Louis University has been awarded a $10,400 grant from E. I. Du Pont de Nemours and Company for the general support of its Institute for the Teaching of Chemistry, it was announced today by Dr. Theodore A. Ashford, Professor of Chemistry and Director of the Institute. This is the second year Du Pont has aided the Institute, which has operated since 1950.

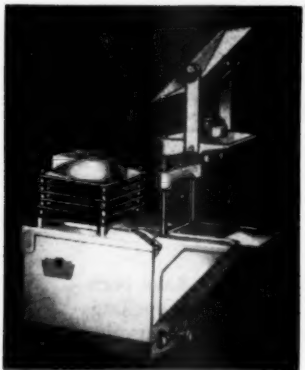
The grant will provide for sixteen fellowships valued at $350 each for Chemistry teachers in High Schools and Junior Colleges, enabling them to attend the University's six-week program of the Institute to be held in the summer of 1956. The applicants need not be candidates for a degree. The Summer Institute program is comprised of five types of activity: special lectures, seminars in special topics of chemistry, seminars on the problems of teaching chemistry, informal conferences and field trips to local industry and laboratories.

The grant will also provide for two fellowships of $1,650 for the support of qualified recent college graduates, who wish to work toward a Master's of Science in the Teaching of Chemistry during the academic year 1956–57. The degree program is tailor-made for graduate training in Chemistry teaching. It combines advanced courses in Chemistry, Physics, Mathematics and Education.

In announcing the grant, Dr. Ashford called attention to the very serious shortage of science teachers and people studying science today, and the concerted effort throughout the country to alleviate the problem. He said that it is a problem which concerns the government, industry, the National Science Foundation, scientific societies and universities.

It is encouraging, he added, that industry has seen fit to support the teaching of Science and Mathematics teachers, and that Du Pont has given its support to aid the Institute at Saint Louis University.

Qualified applicants may write directly to: Dr. T. A. Ashford, Director of the Institute for the teaching of Chemistry, Saint Louis University, Saint Louis, Mo., for further information concerning the fellowships and a bulletin describing the Institute.



CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS, INC.

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Date ....19.........

I hereby apply for membership in the Central Association of Science and Mathematics Teachers, Inc., and inclose \$3.50 for annual membership dues, which includes one year's subscription to SCHOOL SCIENCE AND MATHEMATICS. I will receive nine issues of this journal, none being published in July, August or September. (Subscriptions beginning with January issue expire with December; with October issue expire with June.)

Begin: JANUARY ☐ Begin: OCTOBER ☐

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Underline Section in which enrollment is desired: *Biology, Chemistry, Elementary Science, Elementary Mathematics, General Science, Geography, Mathematics, Physics* ....

Mail this application with \$3.50 (Canada \$3.75, Foreign \$4.00) to Central Association of Science and Mathematics Teachers, Inc., P.O. Box 408, Oak Park, Ill.

PLEASE CHECK IF YOU FORMERLY WERE A MEMBER ☐

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Bibliography should be given thus:
FRANKLIN, G. T. "Analysis in First Year Chemistry," *Journal of Chemical Education,* 7, pp. 361-364, February, 1930.

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Tabular Material should be proportioned to suit page width. All tables should be double ruled at the top just below table number and heading; use single rulings for columns, sub-divisions and bottom. References to illustrations and tables should be by number, as "see Fig. 3," and not to position, as "the following table." It may not be possible to set the drawing or table at a specific position with respect to the discussion.

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